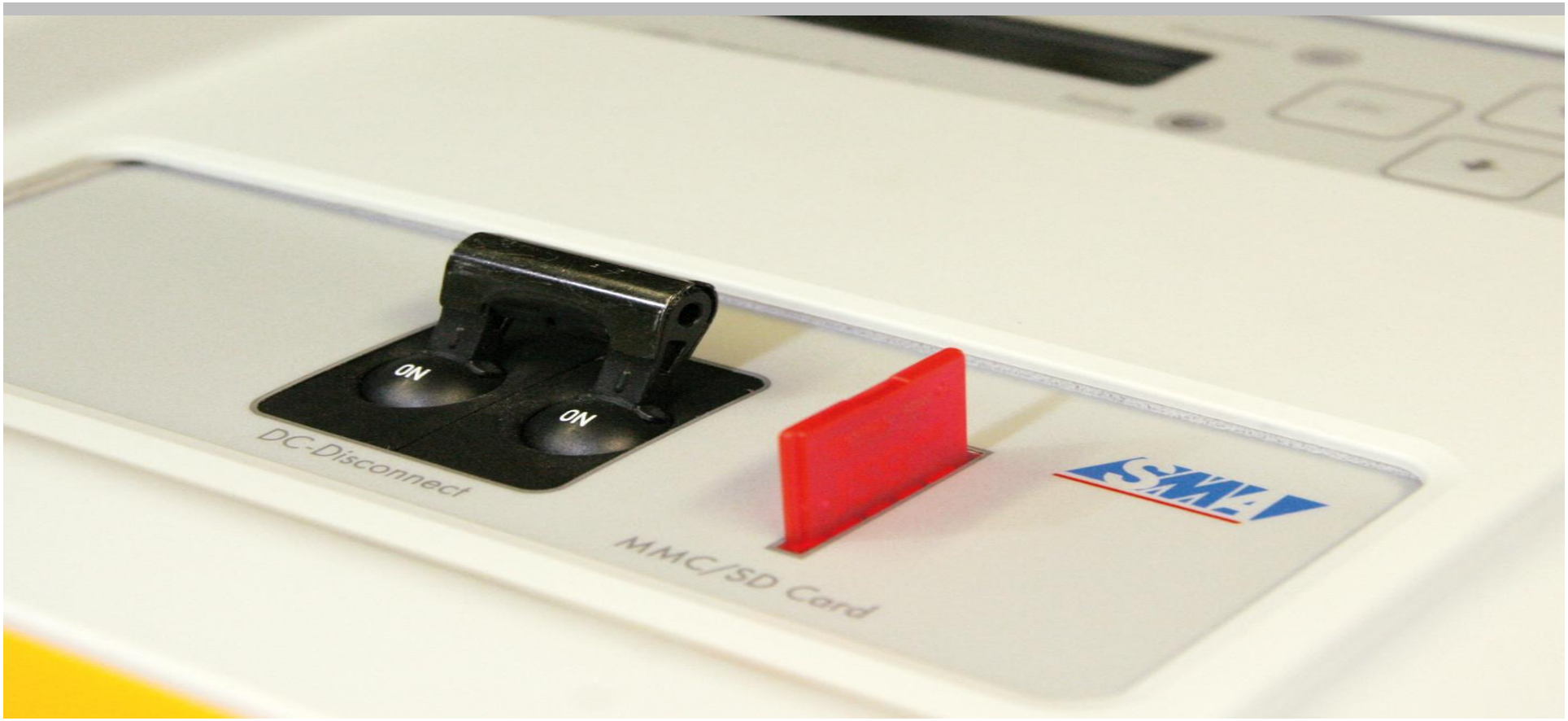
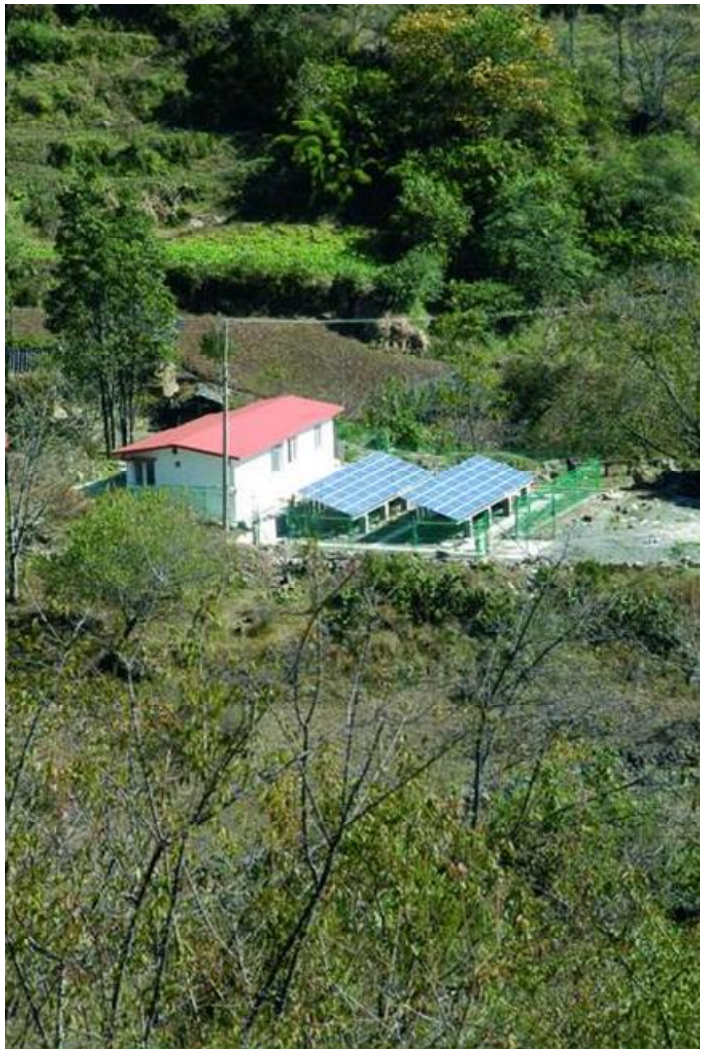
Sunny Island 5048U
Product Training

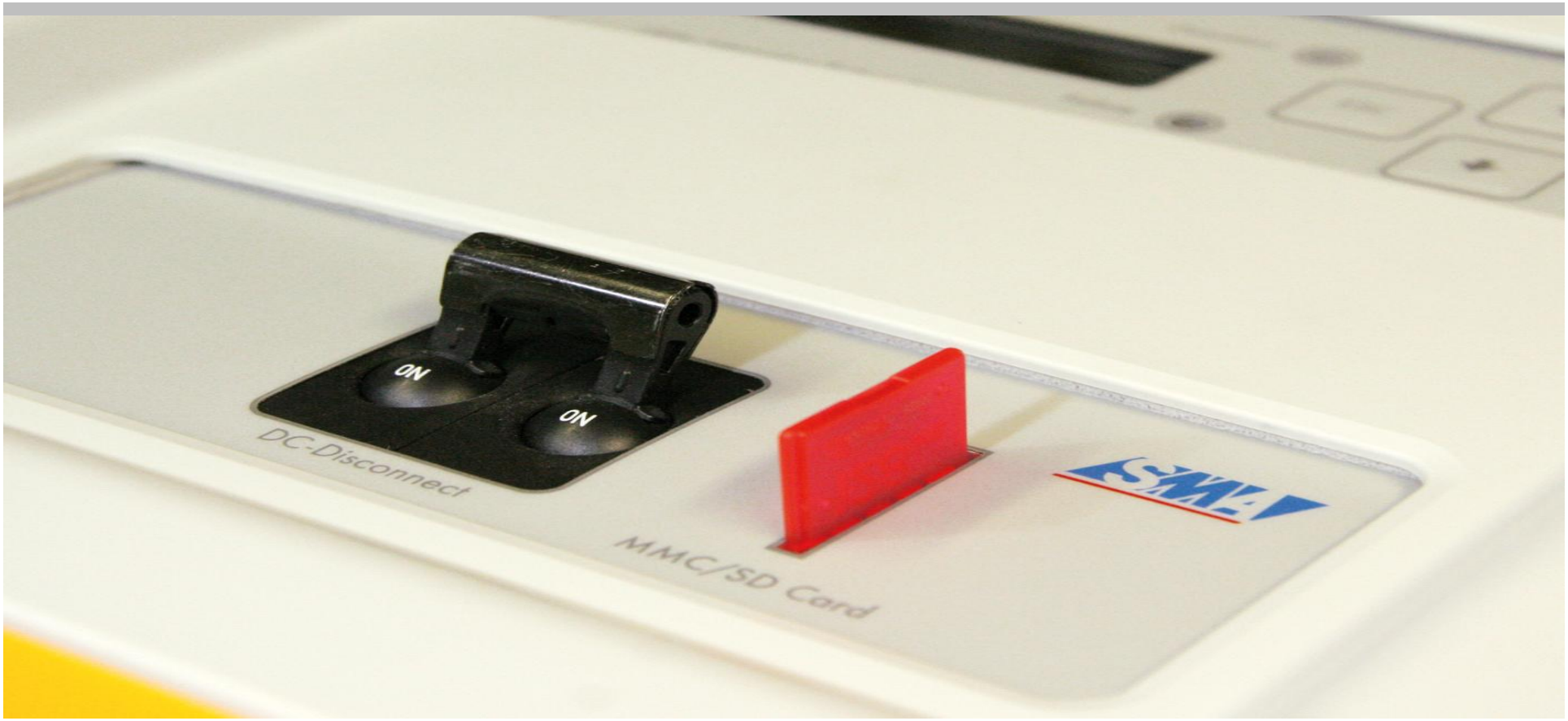


Agenda



- What is Sunny Island ?
- Configuration options
- Hardware and Wiring
- Battery & BMS
- Generators & GMS
- System Management
- MMC/SD card
- Communication

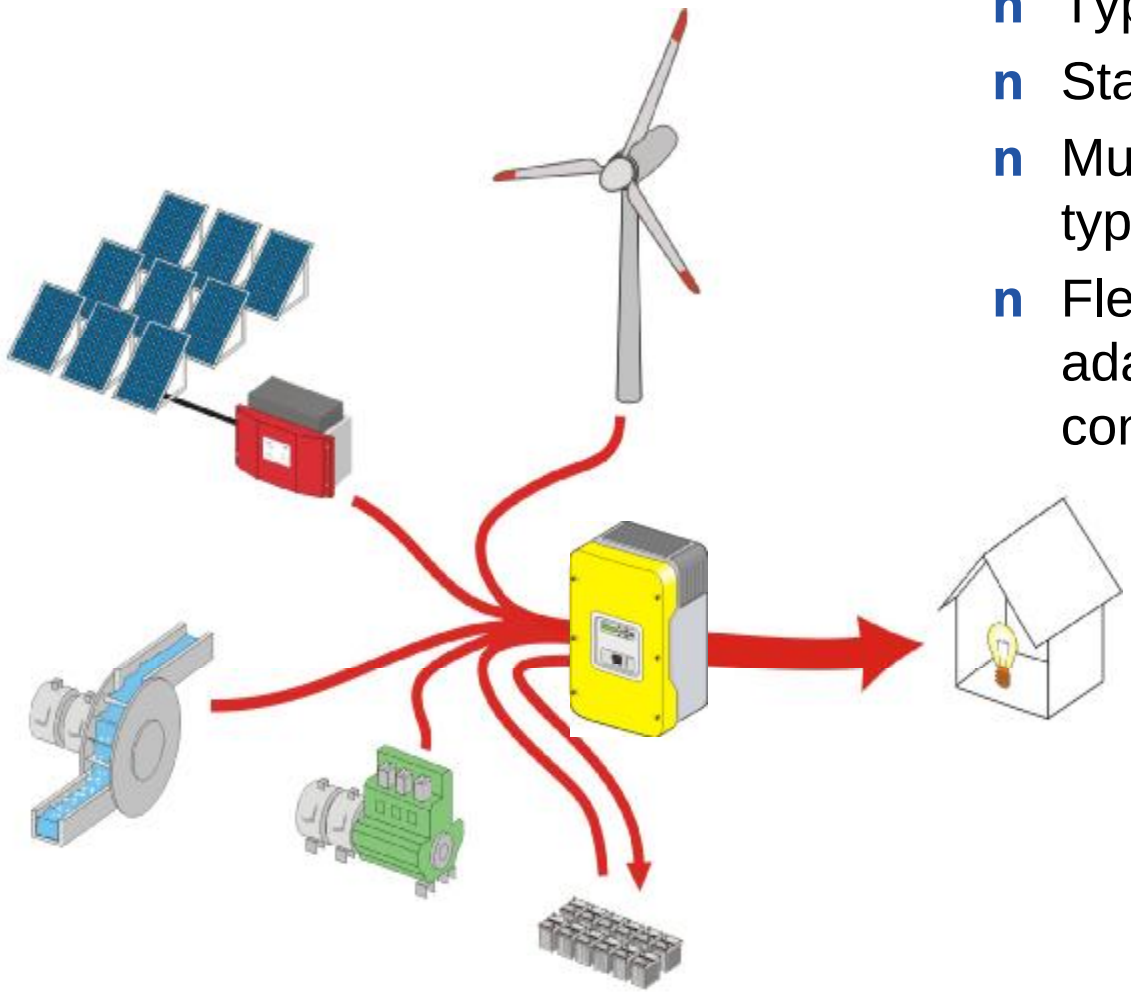
What is Sunny Island 5048U



What is Sunny Island 5048 ?

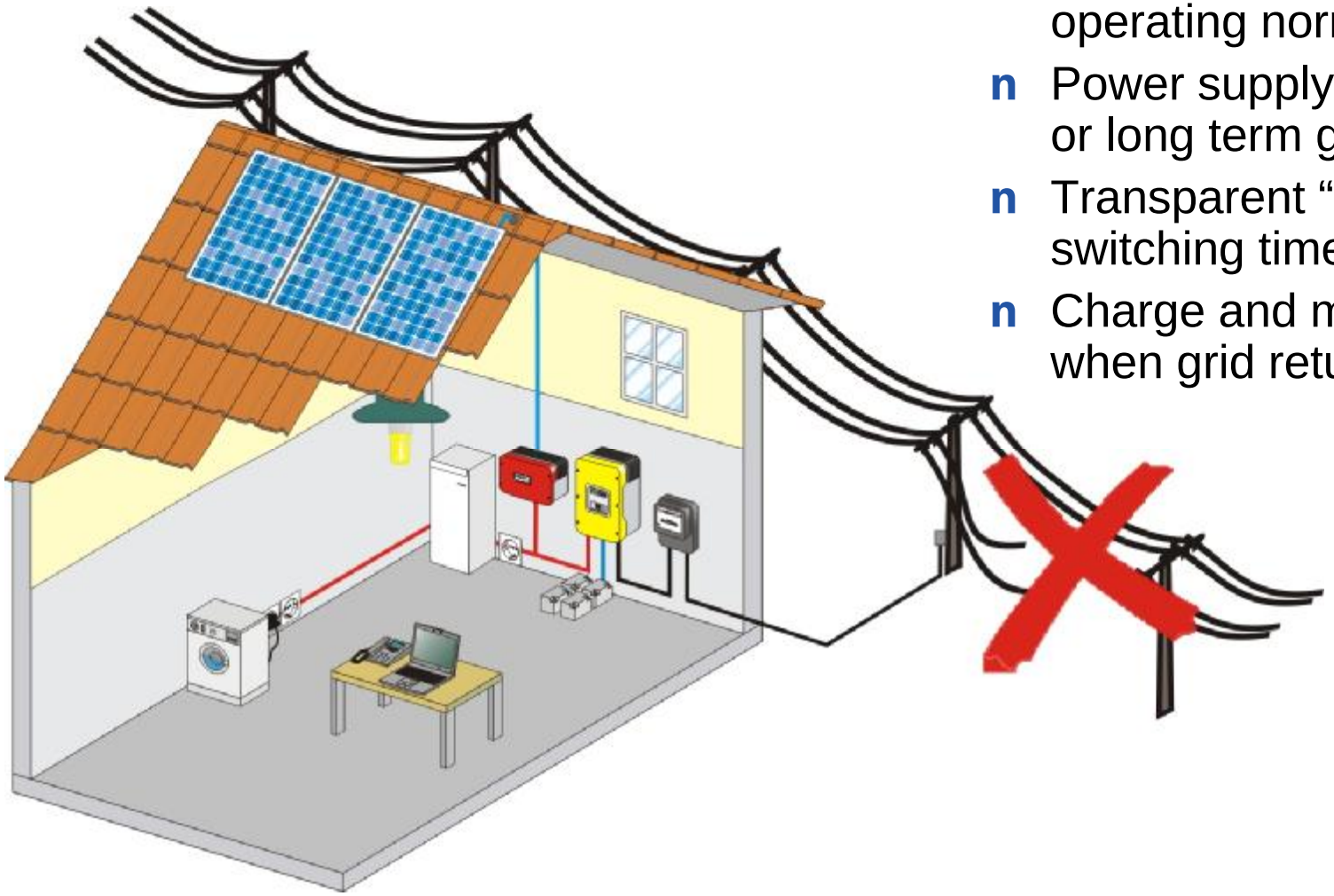
- A modular, bi-directional, battery based inverter designed for off-grid and backup power applications
  - A utility-interactive grid-tied inverter for use with 48 Vdc sources
    - A hybrid system controller for systems with multiple energy sources
      - Battery charge control
      - Generator management
      - System management
    - A data logger and communications device
      - Optimize system performance
      - Troubleshooting
      - Remotely monitor, program and control system

Overview - Off-Grid Power System



- Typically in remote areas
- Stand-alone power supply
- Multiple energy sources are typically present
- Flexible system architecture adapts to local supplies and conditions

Overview - Backup Power System

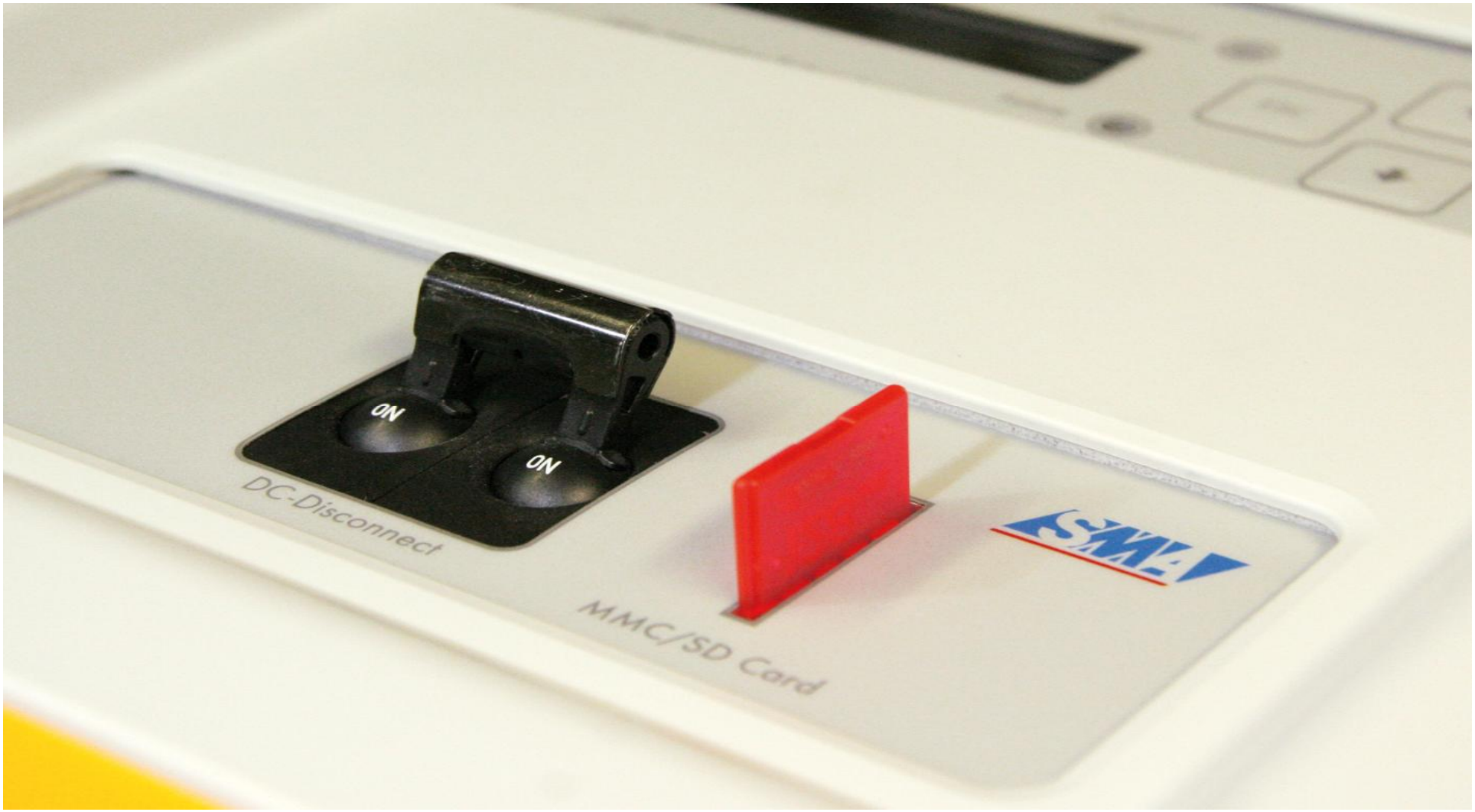


- Grid-feeding when grid is operating normally
- Power supply during short or long term grid failures
- Transparent “near UPS” switching times (16 ms)
- Charge and maintain battery when grid returns

Sunny Island – Basic Tasks

- Grid monitoring
- Grid forming
  - Supply and control of frequency
  - Supply and control of voltage
- Supply of power
  - Supply of active power
  - Supply of reactive power
- Transfer and conversion of energy
  - Conversion from AC into DC for battery charging
  - Conversion from DC into AC for supply of energy
- Control of external loads and energy sources
  - Load control
  - Generator start /stop

Sunny Island Family



Sunny Island Development History

Sunny Island

4500

2001

CHP applications,
Special applications

ROW Only

Sunny Island

4248/4248U

2004

Small systems, Single device applications

US and ROW Versions

Sunny Islands

5048 / 5048U

2007

Multicluster systems, High Power, variety of functions

US and ROW Versions

Sunny Island Products – Overview

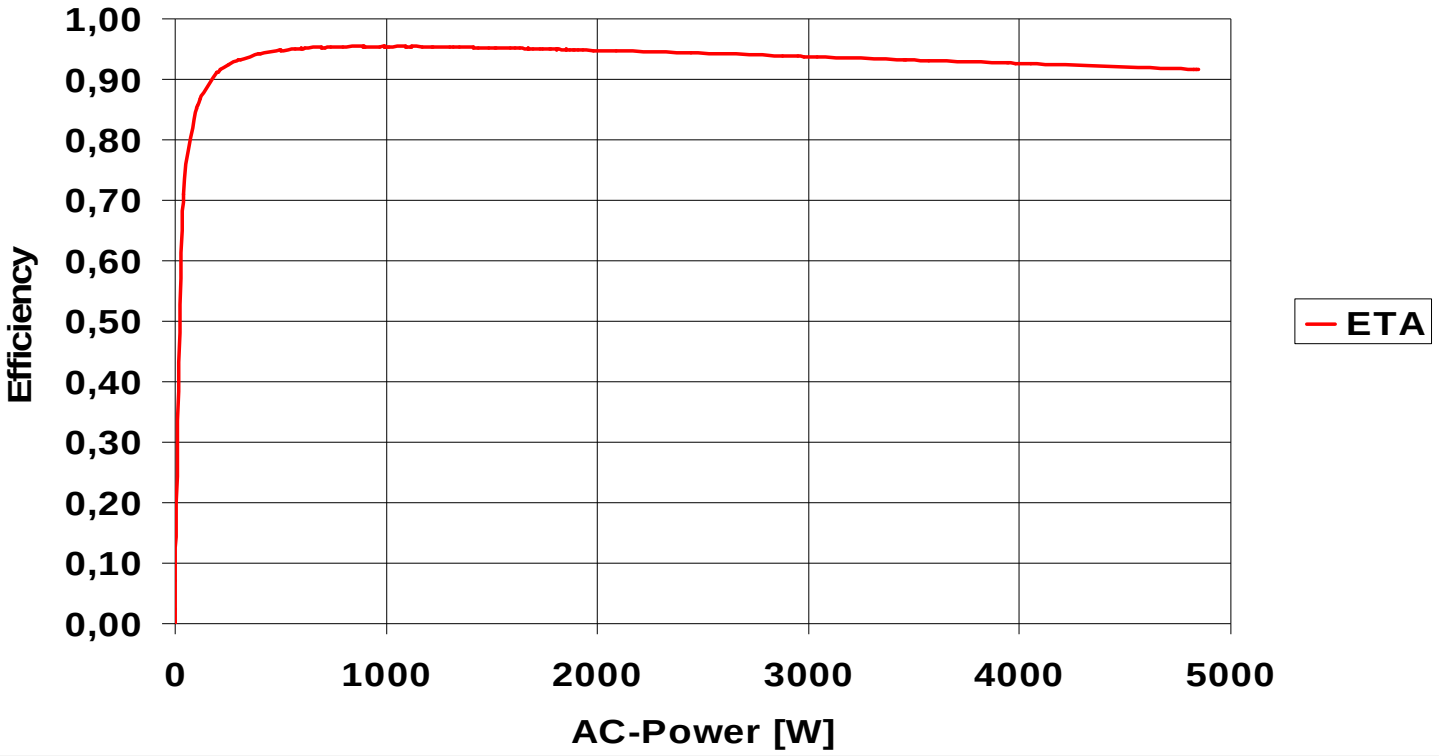
Properties	SI4500	SI4248U	SI5048U
Parallel operation	ü		ü
3-phase operation	ü		ü
Grid and generator support	ü		ü
DC-coupling possible		ü	ü
Extended battery, load and generator management	ü		ü
Quick Configuration Guide		ü	ü
Data logging and Programming with MMC/SD Card			ü

SI 5048U – Technical Data

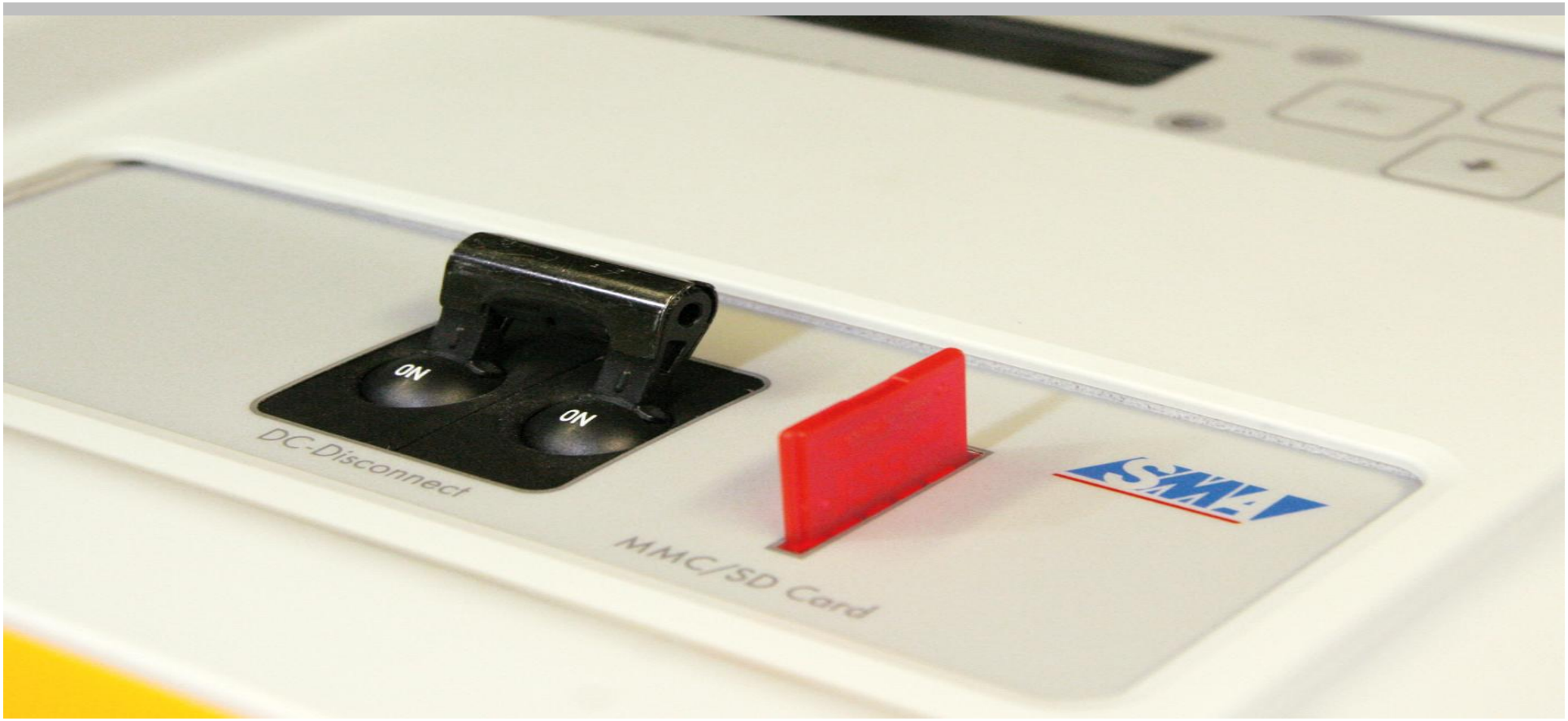
Nominal AC power (25°C)	5.0 kW $_{\text{Continuous}}$	6.5 kW$_{30min}$ / 8.4 kW$_{1min}$
Nominal AC voltage	120 V	
Nominal frequency	60 Hz	
Maximum AC Output current	120 Amps	
Nominal DC voltage	48 V	
Maximum efficiency	>95%	
Integrated Isolation Relay	56 Amps $_{\text{Continuous}}$	112 Amps (26.9 kW) with stacked Sunny Islands
Losses Idle/Standby	25W/4W	
Maximum System Size	1~/2~/3~	20 kW/20 kW/ 15 kW
Other Features	SD/MMC Card, Single Point of Operation AC Coupling/DC Coupling/Both	

Efficiency optimized for off grid systems

- High efficiency in both invert and charge modes
  - Max. Efficiency > 95 %
  - Optimized for low load operation (η > 90 % from P= 5 - 100%)
  - Power dependant “sleep mode” for parallel slave units



Sunny Island 5048U
Hardware and Connections



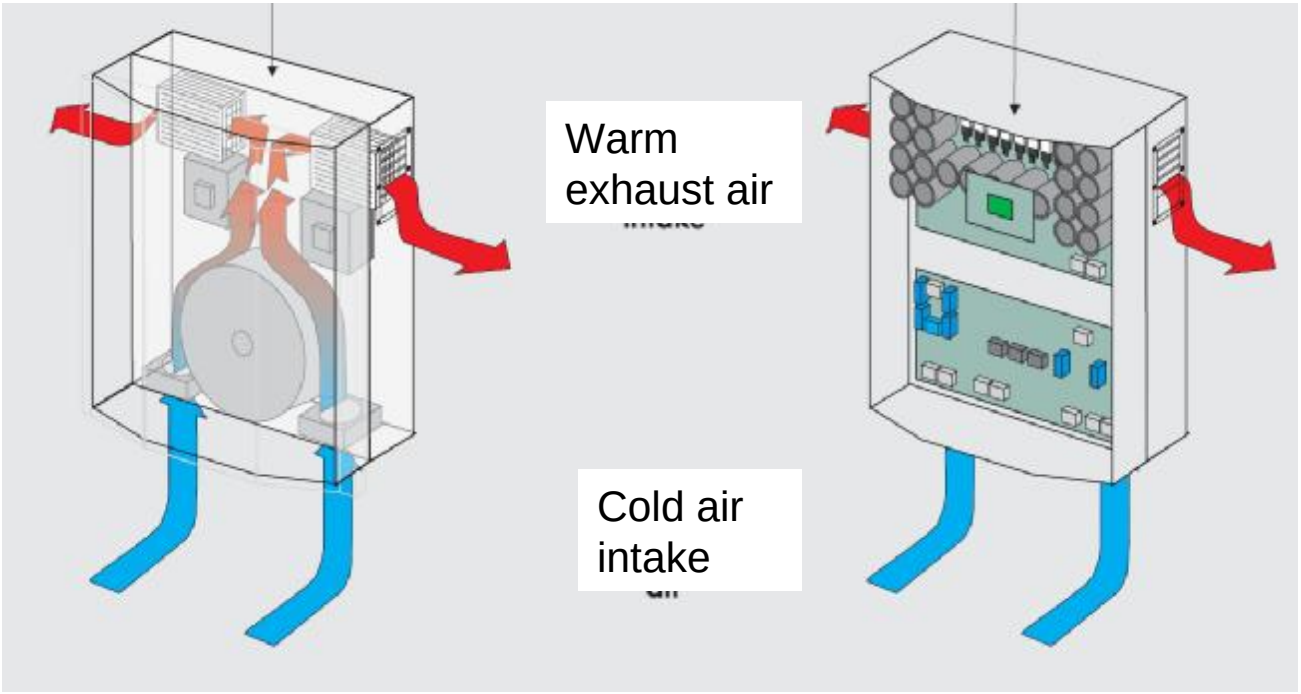
Front Panel - Easy To Use

- Single Point of Operation
  - Master unit is the only user interface
    - Settings, observe values, initiate switching & timers
  - Master unit monitors and controls Slave units
    - Software updates at Master, Master updates the Slaves

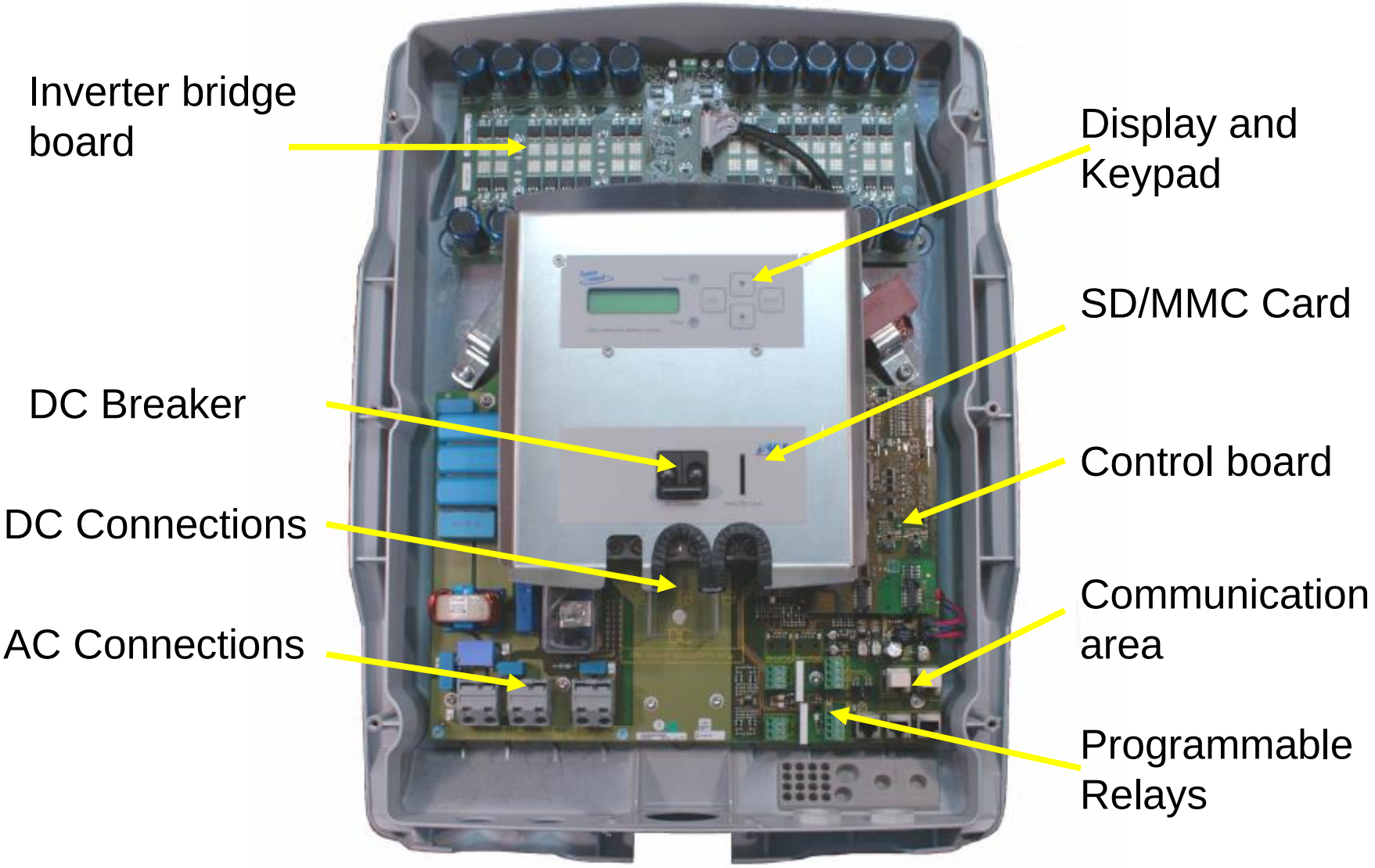
- Integrated MMC Card
  - Logging of all data and parameters (last 100 Days)
  - Logging of all event, warning, and failure messages (last100 Days)
  - Software-Update via MMC Card
  - Logging of all settings and parameters on MMC Card

Sunny Island Enclosure

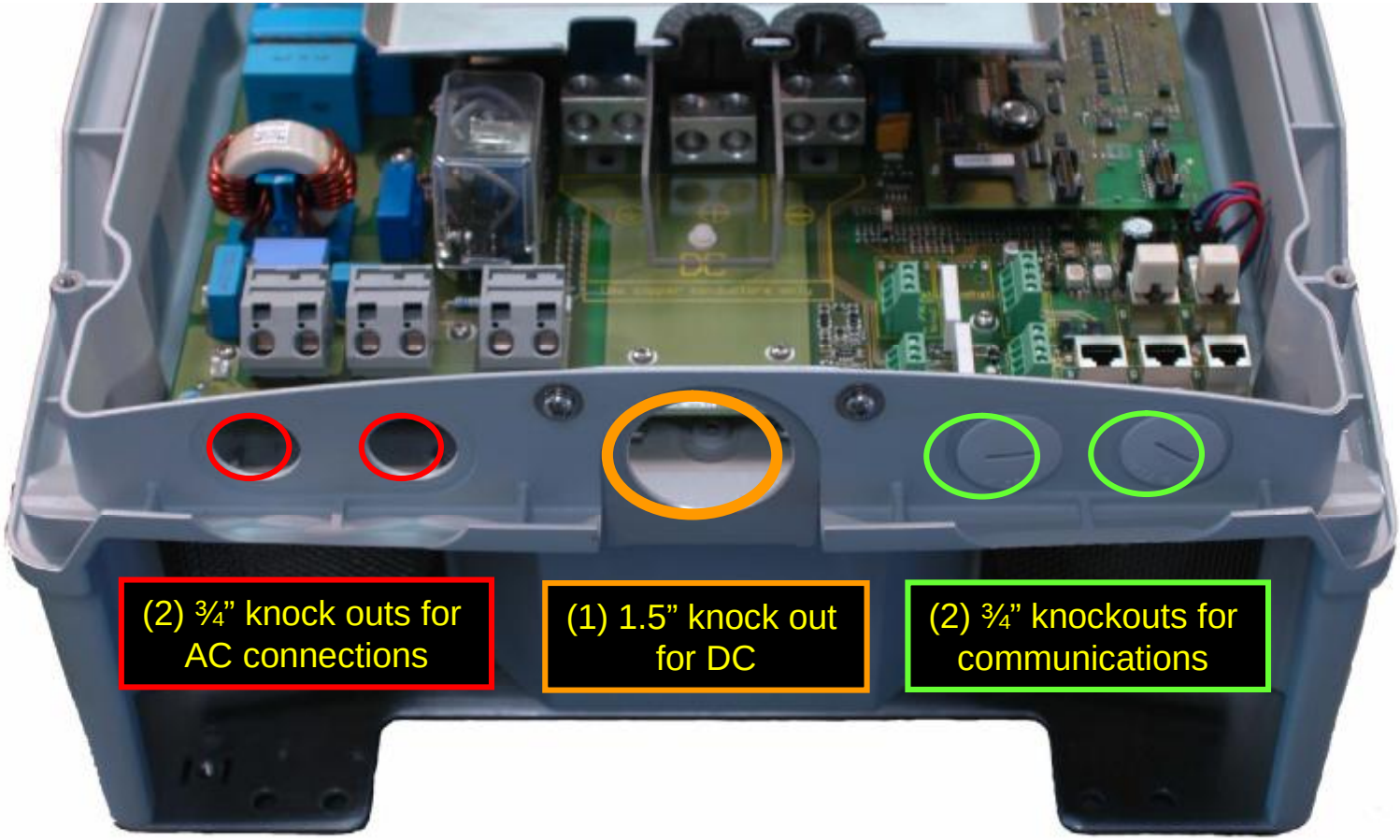
- Corrosion resistant painted die cast aluminum
- Incorporates SMA‘s patented Opticool system
  - No air blowing on sensitive electronics
  - Large ambient temperature range (-25 to +50°C)
  - Maintains output power at high temperatures (4 kW at 45°C)



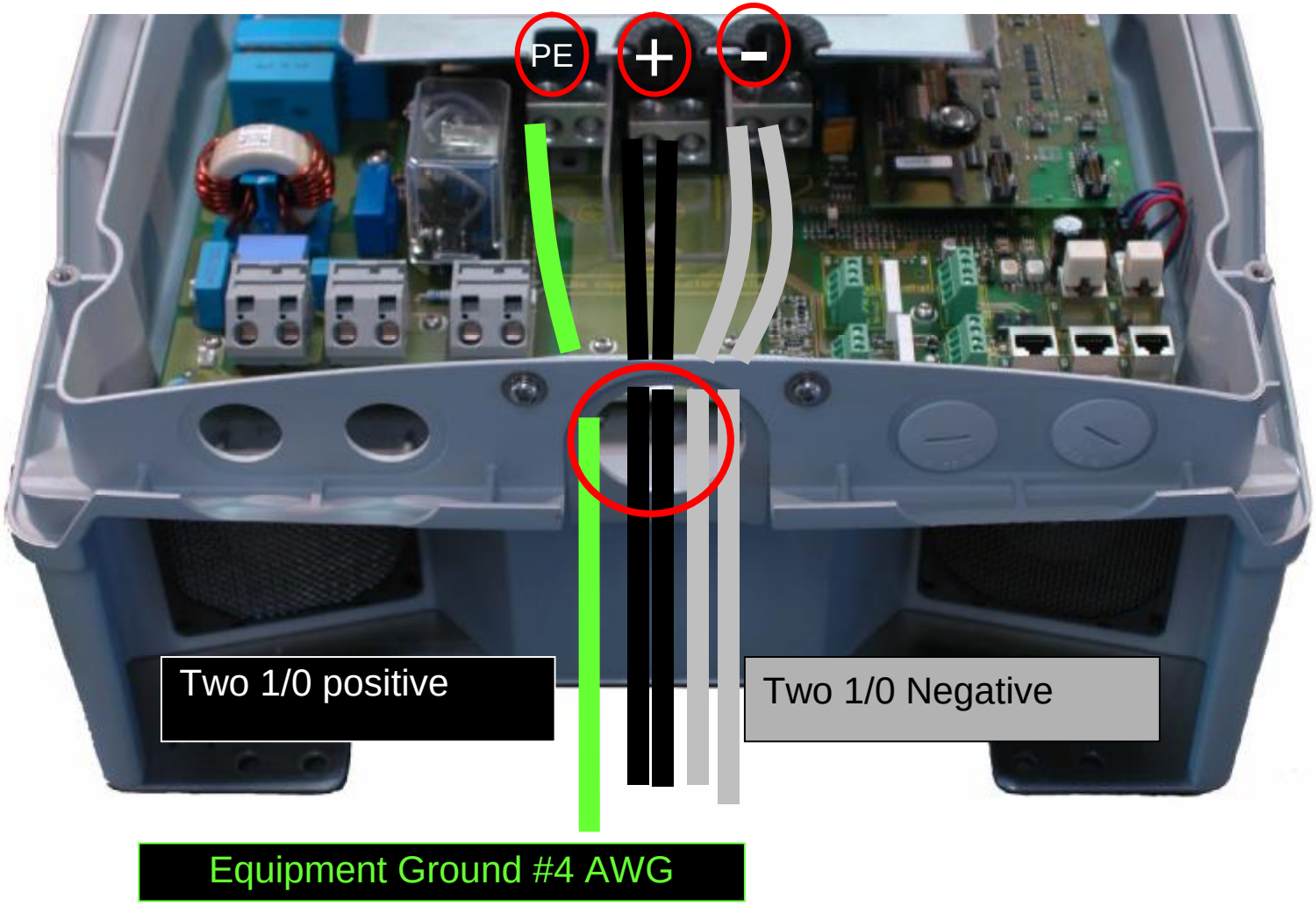
Sunny Island 5048 – Interior View



Sunny Island 5048 – Knockouts



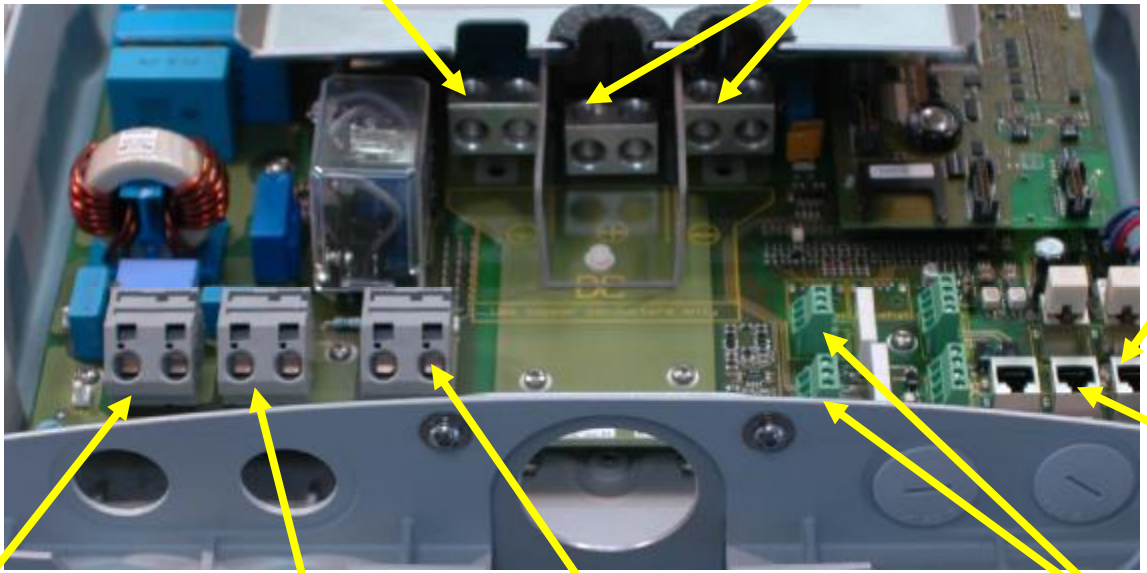
1 ½ ” knock out for DC Conductors



Sunny Island 5048 – Wiring

* DC Equip. Ground– 1/0

DC Pos./Neg. – Dual 1/0



Communication Cables
RJ-45 “Ethernet”

CAN Buss for Inverter control

AC1 L/N
AWG 6/4

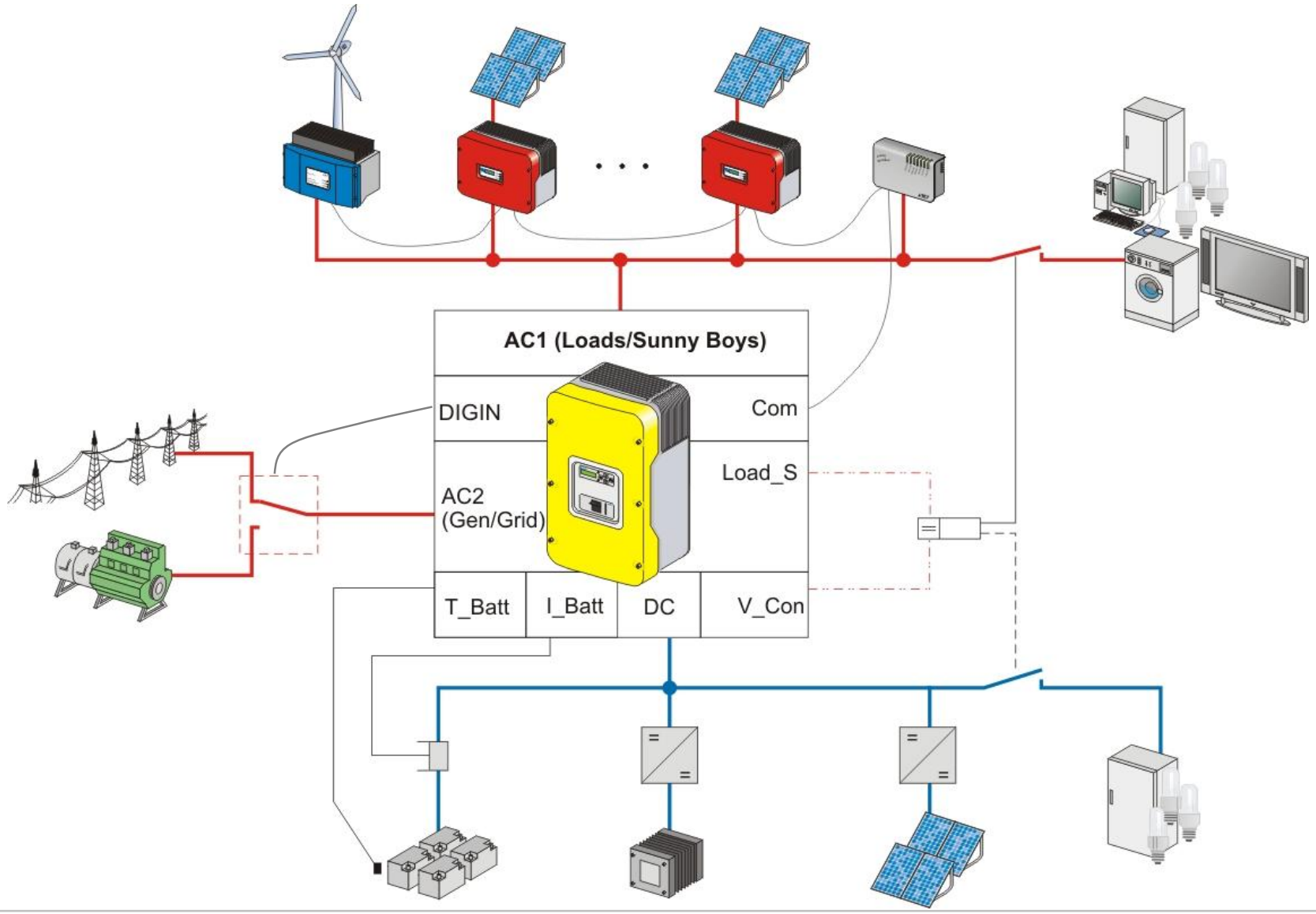
AC2 L/N
AWG 6/4

AC Equip. Ground
AWG 6/4

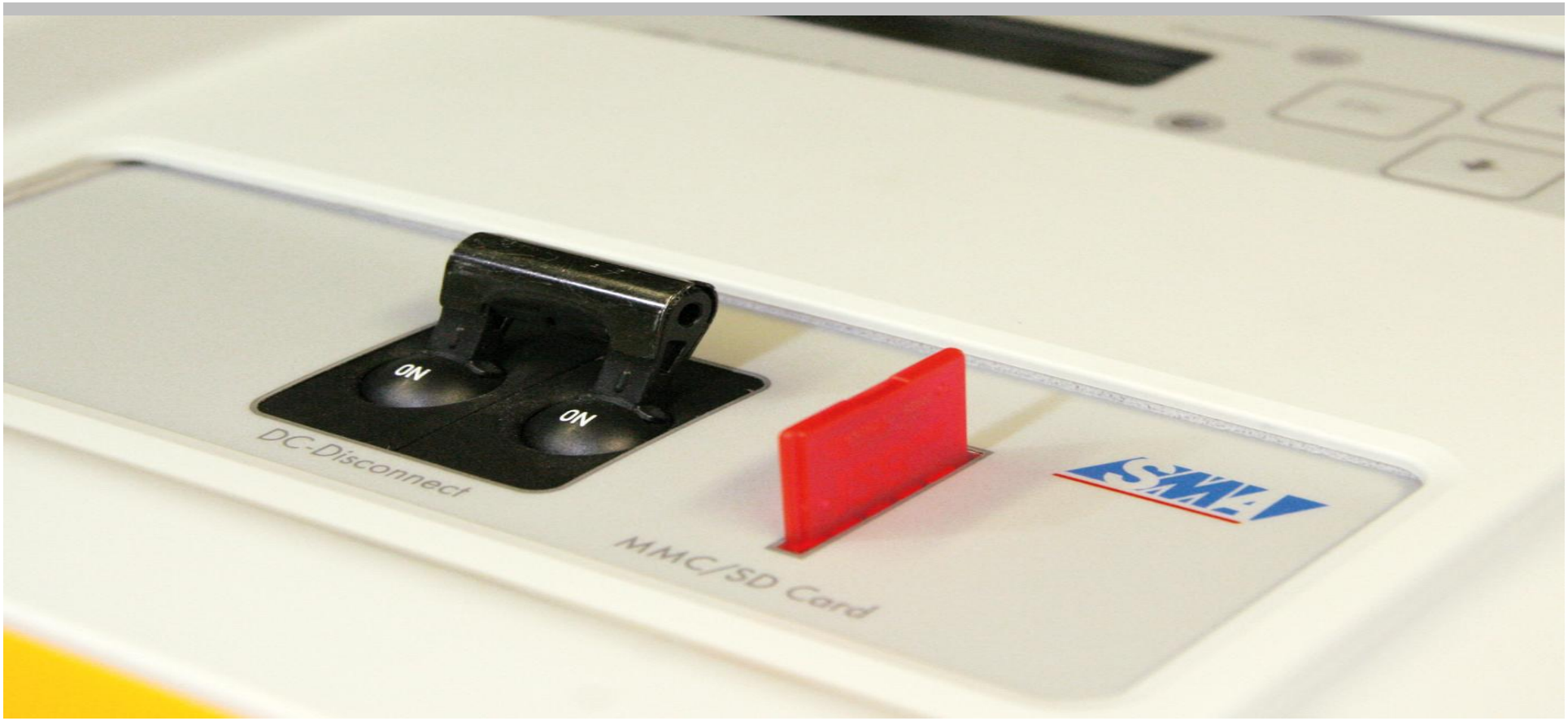
Control Relays
AWG 24 typical

* Suggestion: Ground DC negative at battery terminal

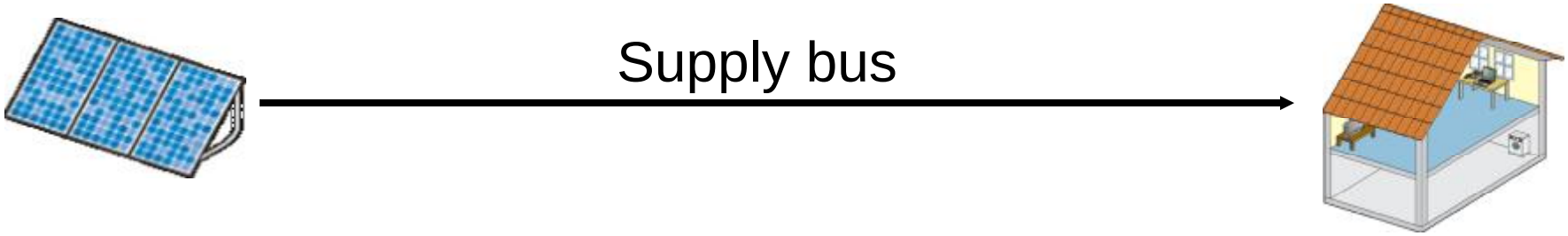
Connections to Sunny Island 5048



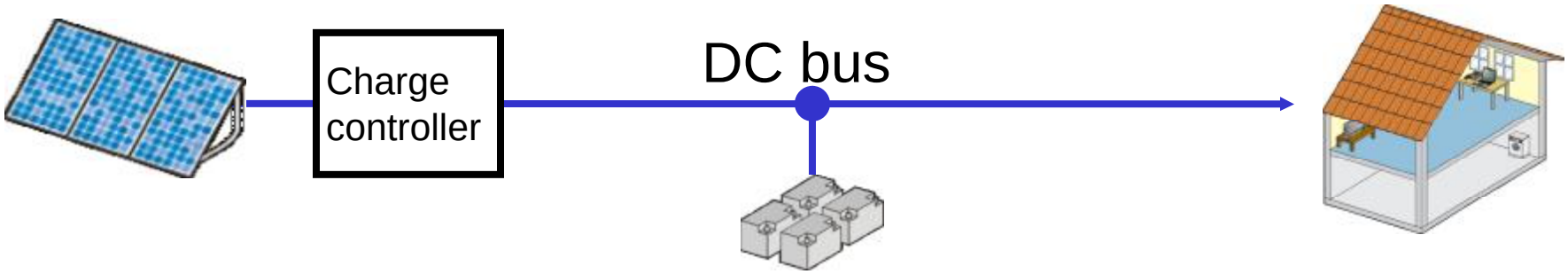
Sunny Island 5048U
AC and DC Coupling



What is “Coupling“?

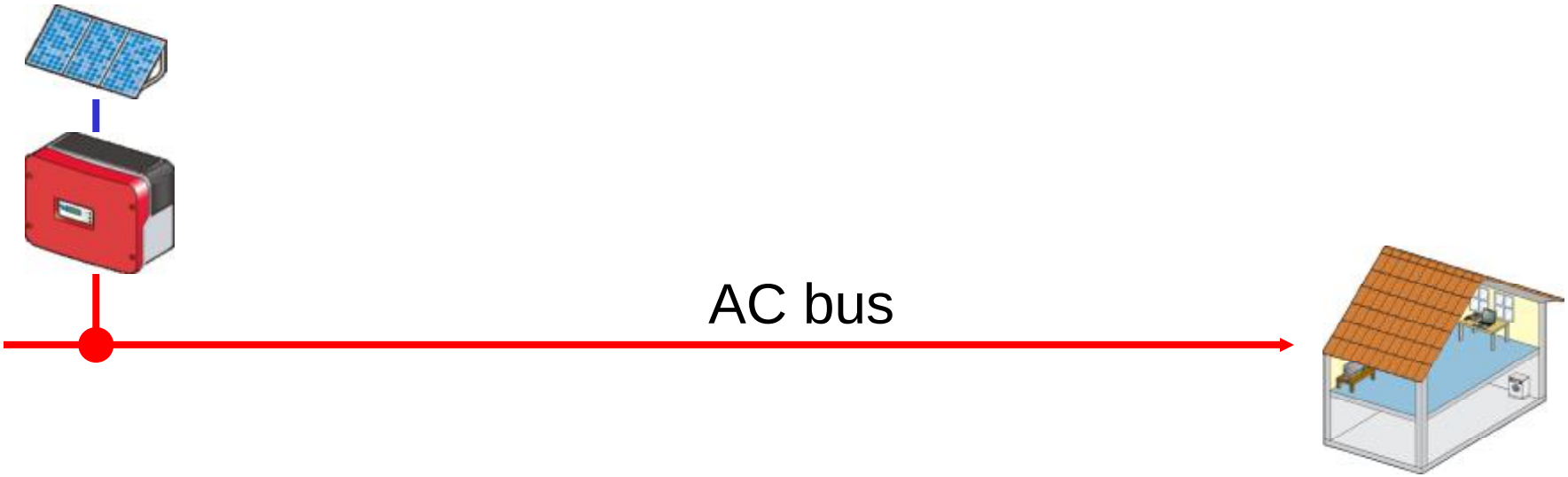


- Supply line from the source to the load forms a “bus“



- DC coupling: Connection of sources and loads via a DC bus

AC Coupling

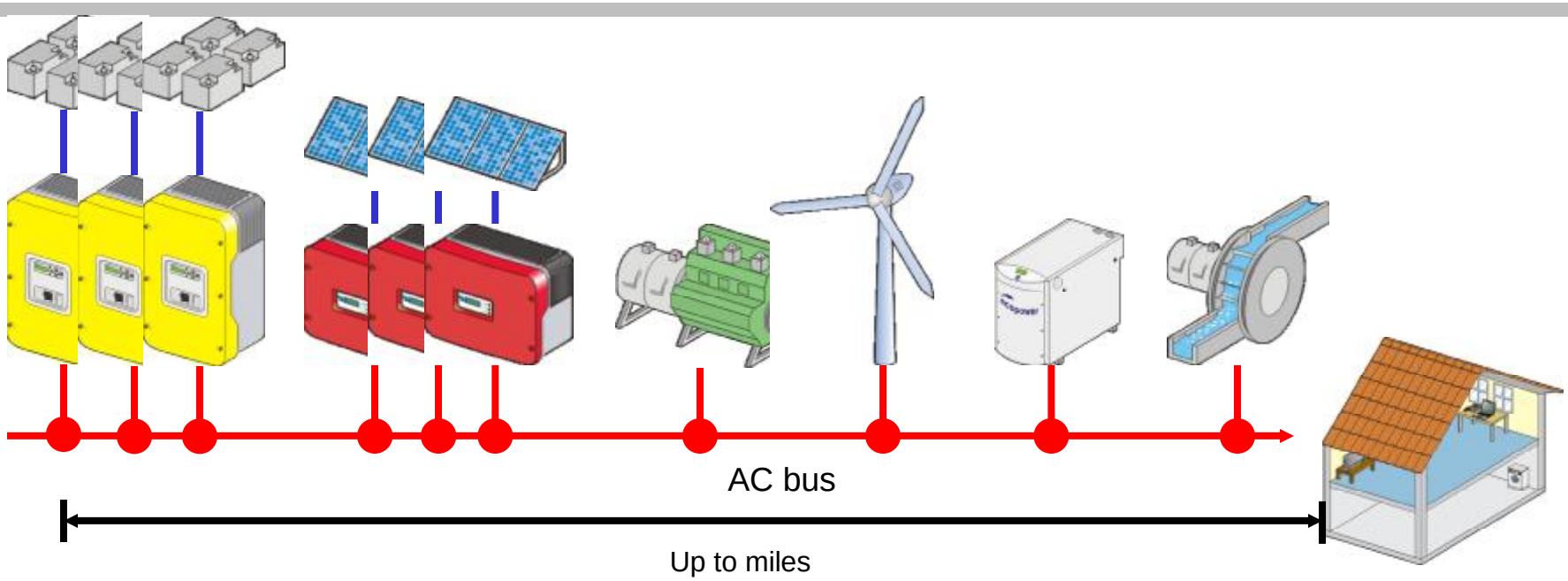


- AC coupling: Connection of sources and loads via an AC bus

Advantages of AC Coupling: Planning

- Simple design
  - Manageable
  - Modular
- Special knowledge is not required
  - Standard energy sources
  - Standard installation technologies can be used
- Little efforts
  - Low planning costs
  - Little planning time

Advantages of AC Coupling: Flexibility



- Large selection of loads, energy sources, and system components
- Great distances between components are possible
- Simple expansion even after some years

Advantages of AC Coupling: Components

- Independent selection of components
  - Free choice due to grid compatibility
  - Free choice due to variety of AC sources
  - Free choice due to variety of AC loads

- Low costs of components due to
  - strong market competition
  - availability almost worldwide

Advantages of AC Coupling: Expandable

- Adding Sunny Islands
  - without changing other components
  - without reconfiguring the wiring
  - independent of distances

- Extension of phase number
  - from 1-phase to 3-phase
  - from 1-phase to split phase

- Increase of source power without additional costs

- Addition of loads without additional costs

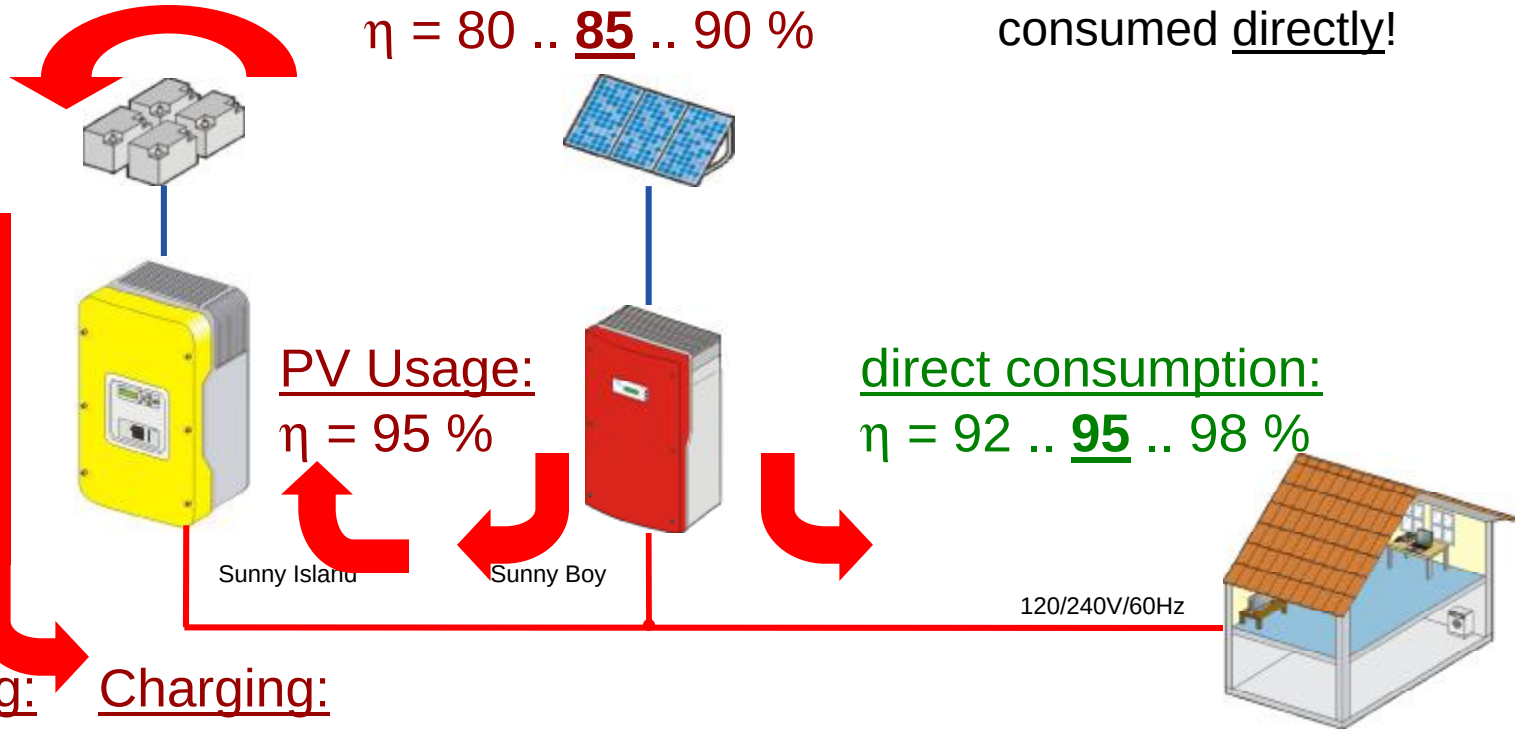
Efficiency with AC coupling (92% Inverter)

NiCd-Battery:
η = 55 .. **60** .. 65 %

LiIon-Battery:
η = 90 .. **92** .. 95 %

Lead acid battery:
η = 80 .. **85** .. 90 %

Assumption: **40 %** of energy is consumed directly!



Discharging:
η = 92 %

Charging:
η = 90 .. **92** .. 95 %

Direct Consumption = E x 40 % x 95 % = 38 % E

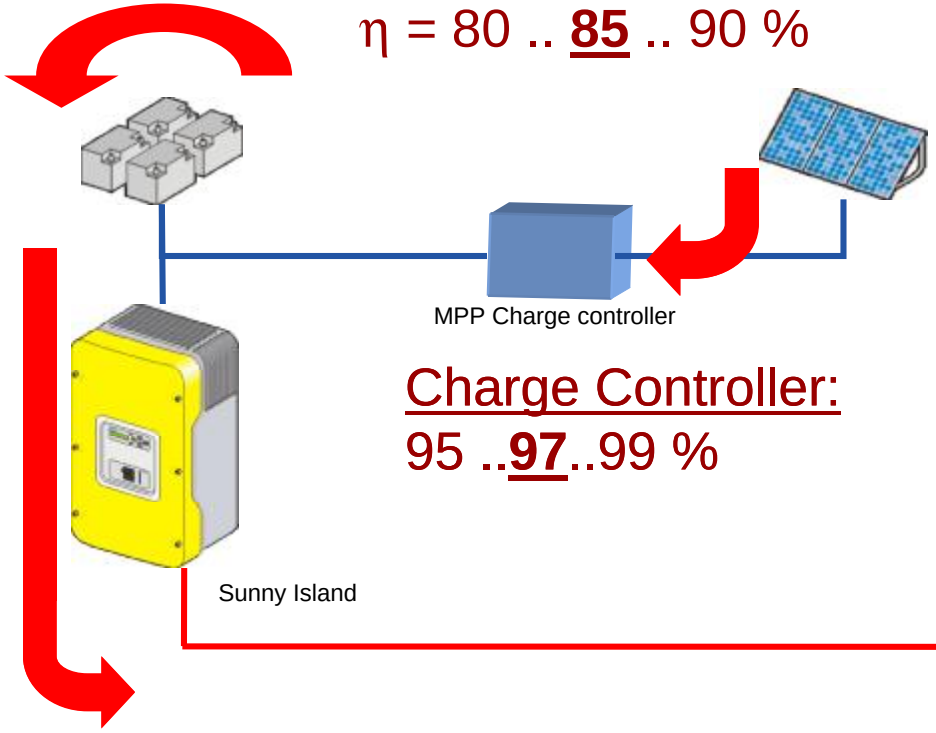
Via Battery = E x 60 % x 95 % x 92 % x 85 % x 92 % = 41 % E

} å **79 %**

Efficiency of MPP DC coupling (92% inverter)

Lead acid battery:
η = 80 .. **85** .. 90 %

Assumption: **40 %** of energy is consumed directly!



Charge Controller:
95 ..**97**..99 %

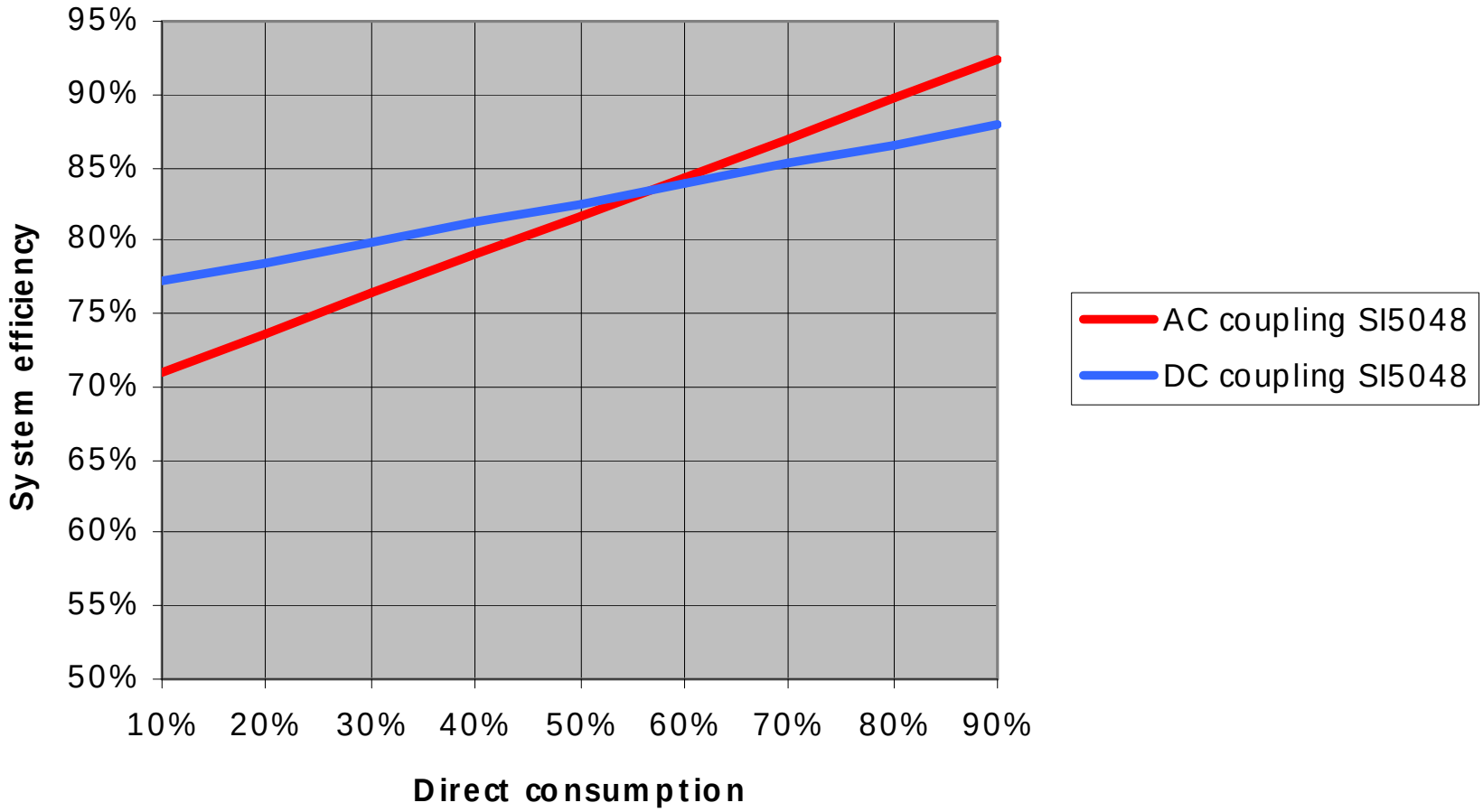
Inverter:
88.. **92**..94 %

Direct consumption = E x 40 % x 97 % x 92 % = 36 % E

Over Battery = E x 60 % x 97 % x 85 % x 92 % = 45 % E

} å **81 %**

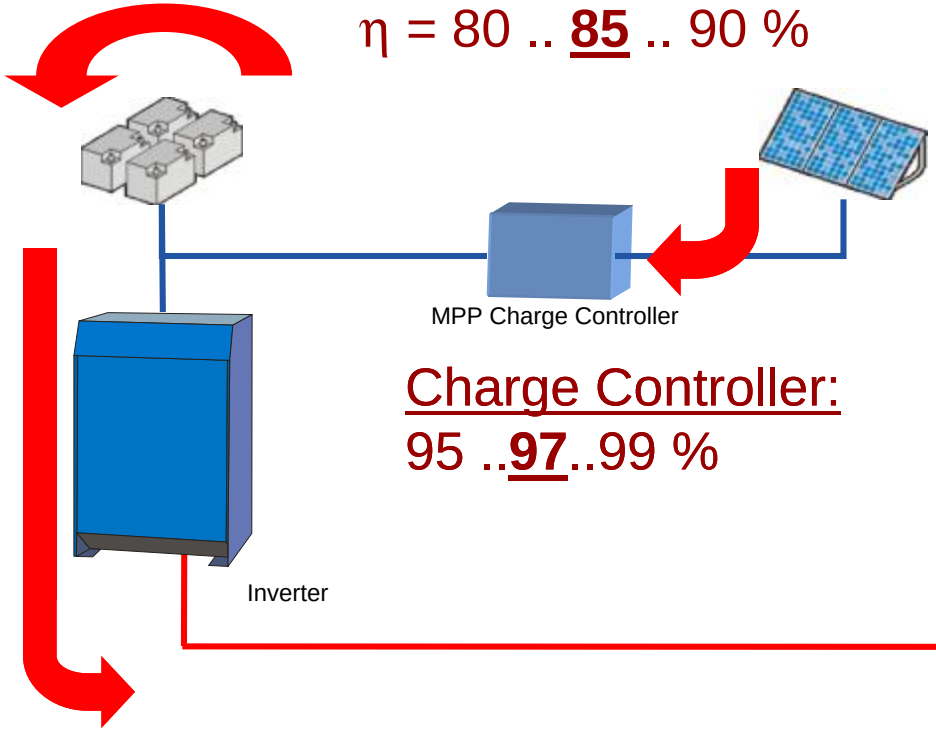
Efficiency with MPP DC coupling (92% inverter)



Efficiency with MPP DC coupling (90% Inverter)

Lead acid battery:
η = 80 .. **85** .. 90 %

Assumption: **40 %** of energy is consumed directly!



Charge Controller:
95 ..**97**..99 %

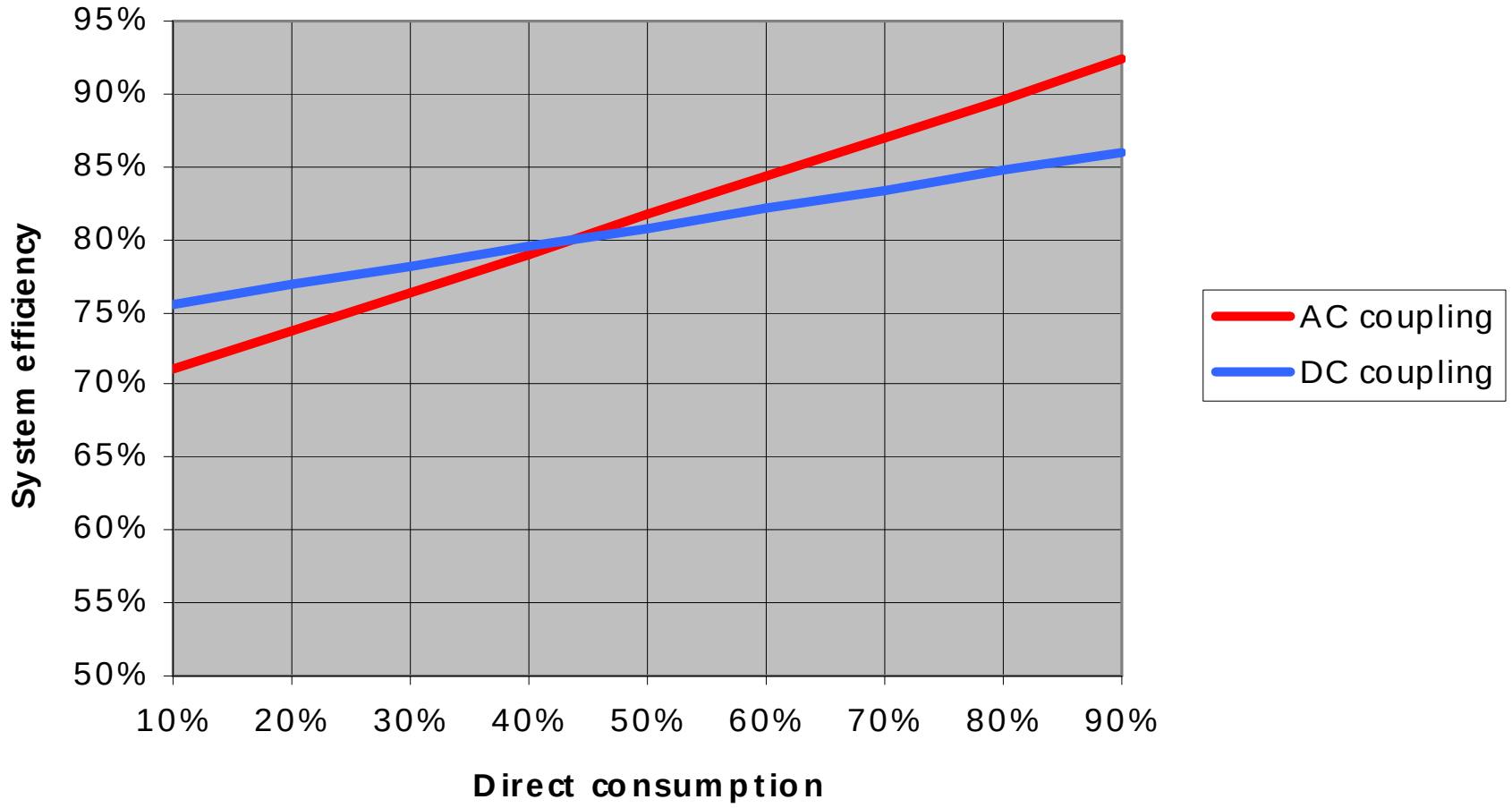
Inv:
85.. **90**..94 %

Direct consumption = E x 40 %x 97 % x 90 % = 35 % E

Over battery = E x 60 % x 97 % x 85 % x 90 % = 44 % E

} å **79 %**

Efficiency with MPP DC coupling (90% inverter)

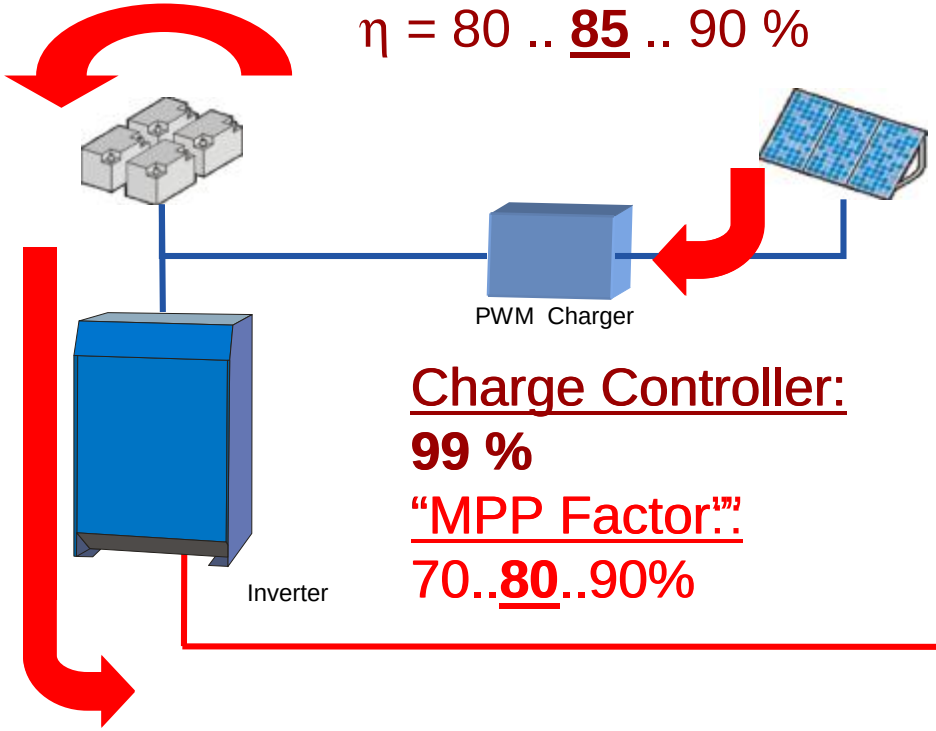


Efficiency with PWM DC coupling

Lead acid battery:

η = 80 .. **85** .. 90 %

Approach: 40 % are consumed directly!



Charge Controller:

99 %

"MPP Factor":

70..**80**..90%

Inv:

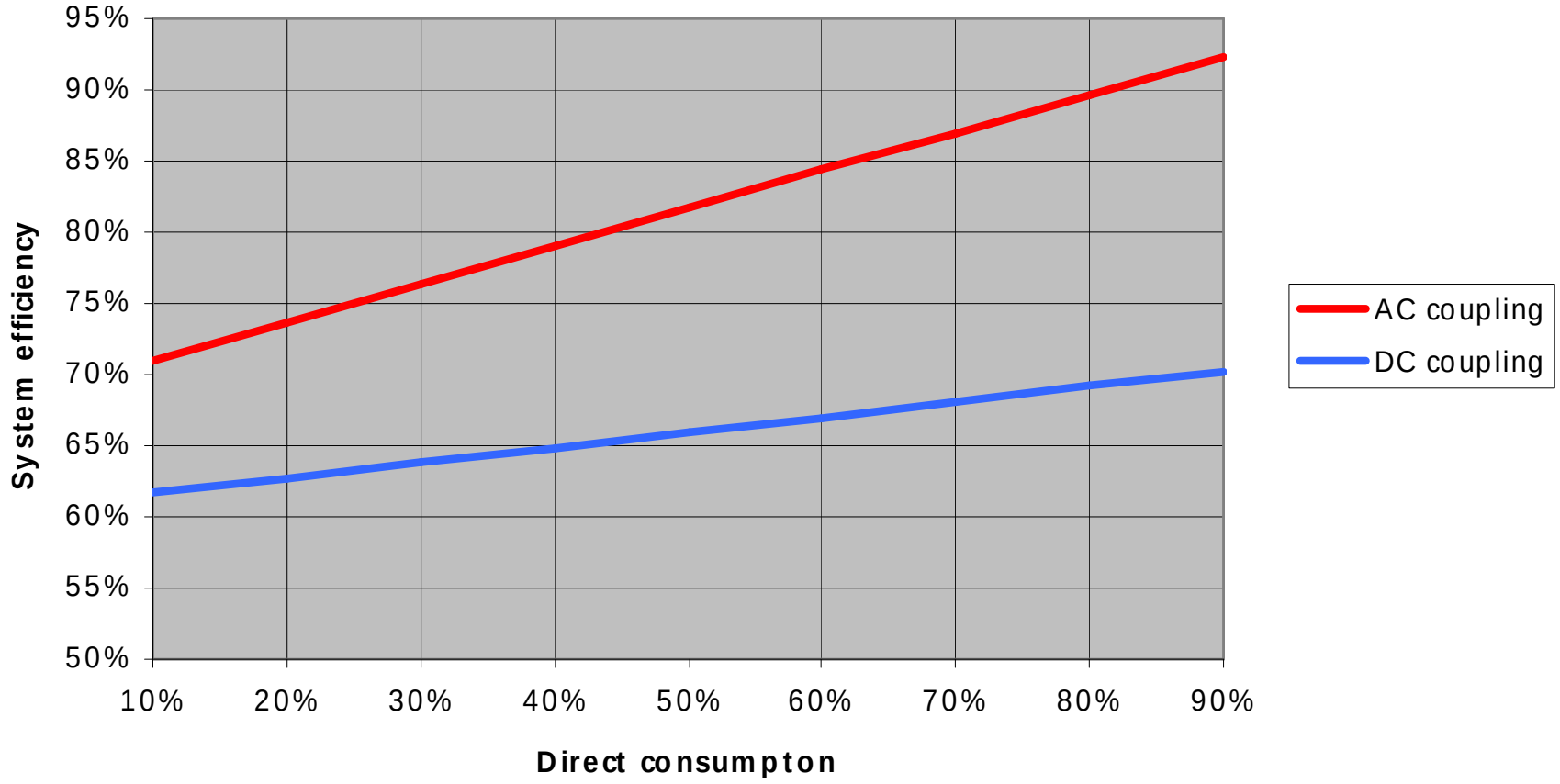
85.. **90**..94 %

Direct consumption = E x 40 % x 99 % x 80% x 90 % = 29 % E

Over battery = E x 60 % x 99 % x 80% x 85 % x 90 % = 36 % E

} å **65 %**

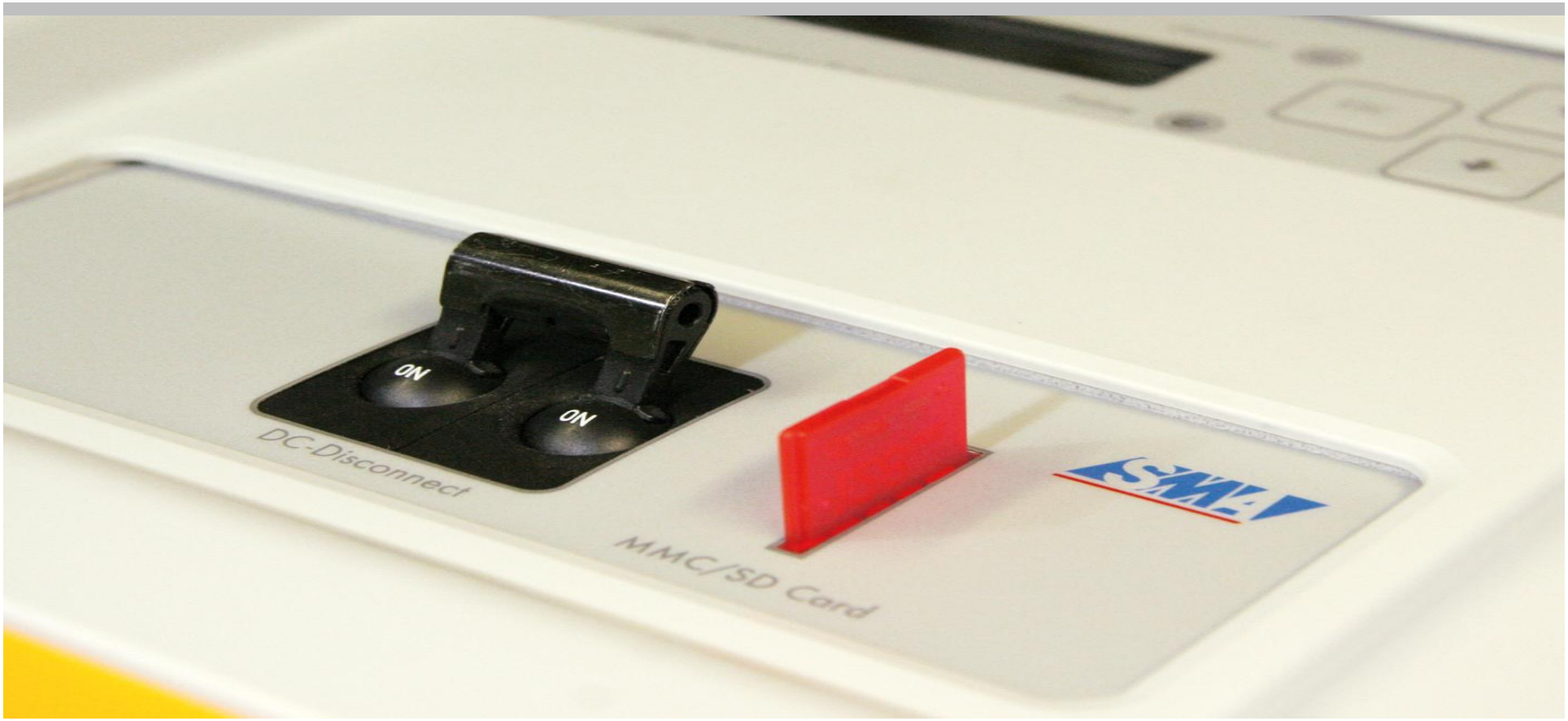
Efficiency with PWM DC coupling



Overview of AC / DC Coupling

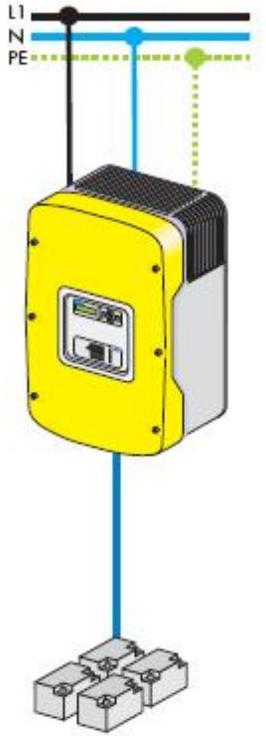
Requirement	AC Coupling	DC Coupling
Installation	++ standard	- specific
Distances	+ in the miles range	- - in the feet range
Extensibility	++ extendable	0 very limited
Costs	++ standard products, modular	- - expensive loads/wiring
Loads to be supplied	++ all	- Dc only
Power	++ up to MW	- - lower kW range
Black Start Capability	- limited – requires load shed relay function	++ occurs automatically

Sunny Island 5048U
System Configuration Options



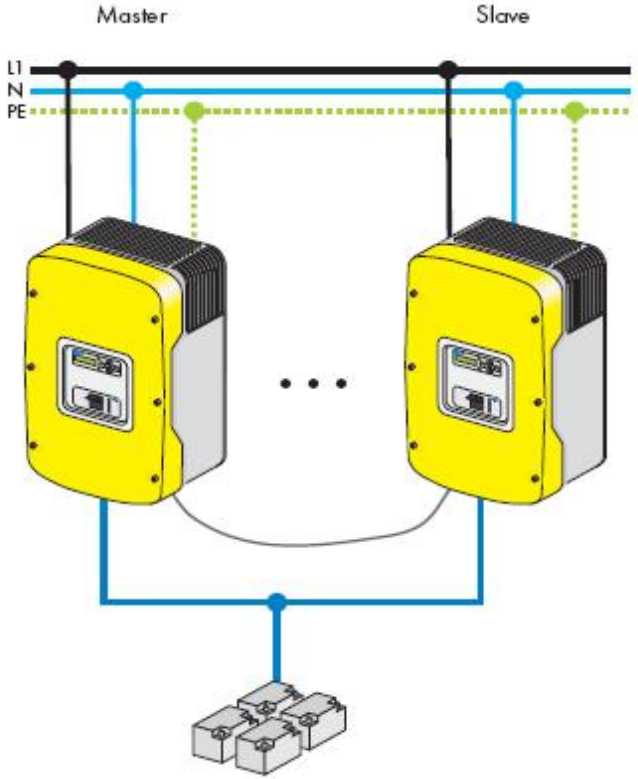
Single Phase Configuration (120V)

1-phase,
120 Vac, 5 kW



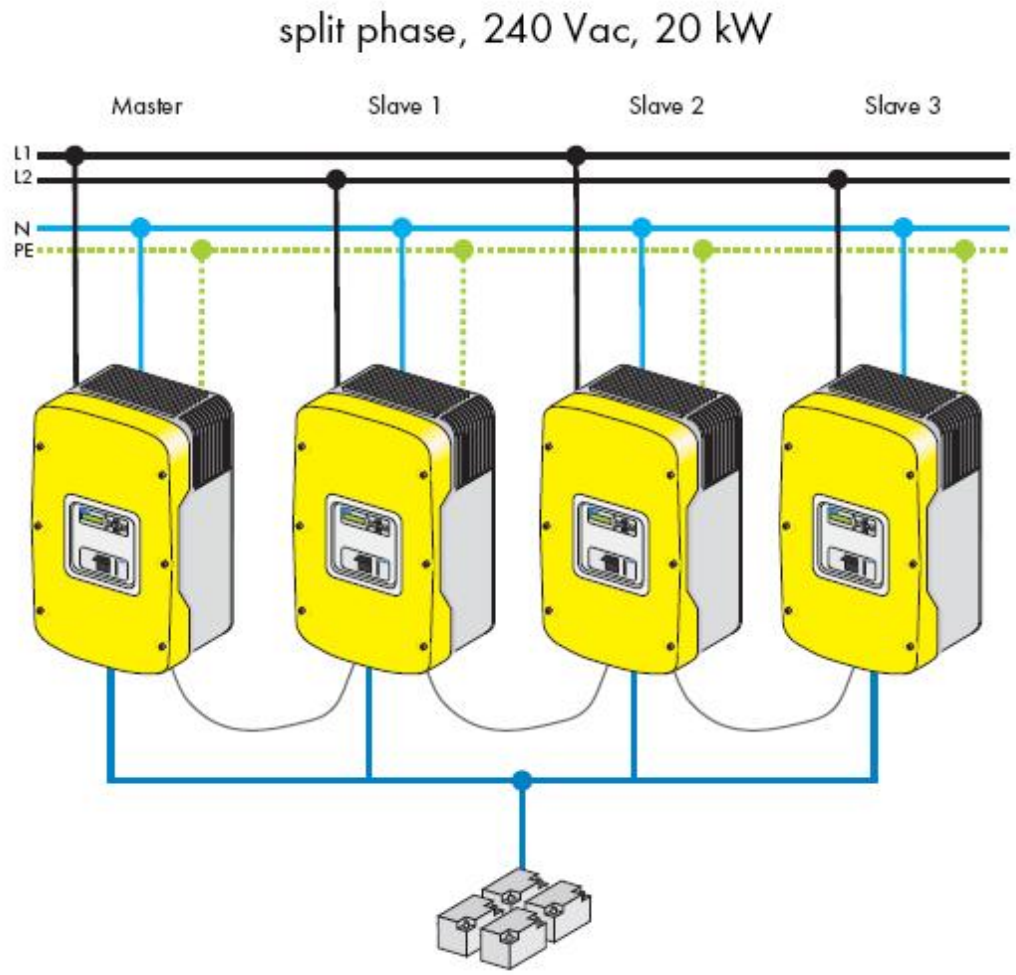
Stand-alone plus optional 120/240V autoformer

1-phase parallel,
120 Vac, up to 20 kW

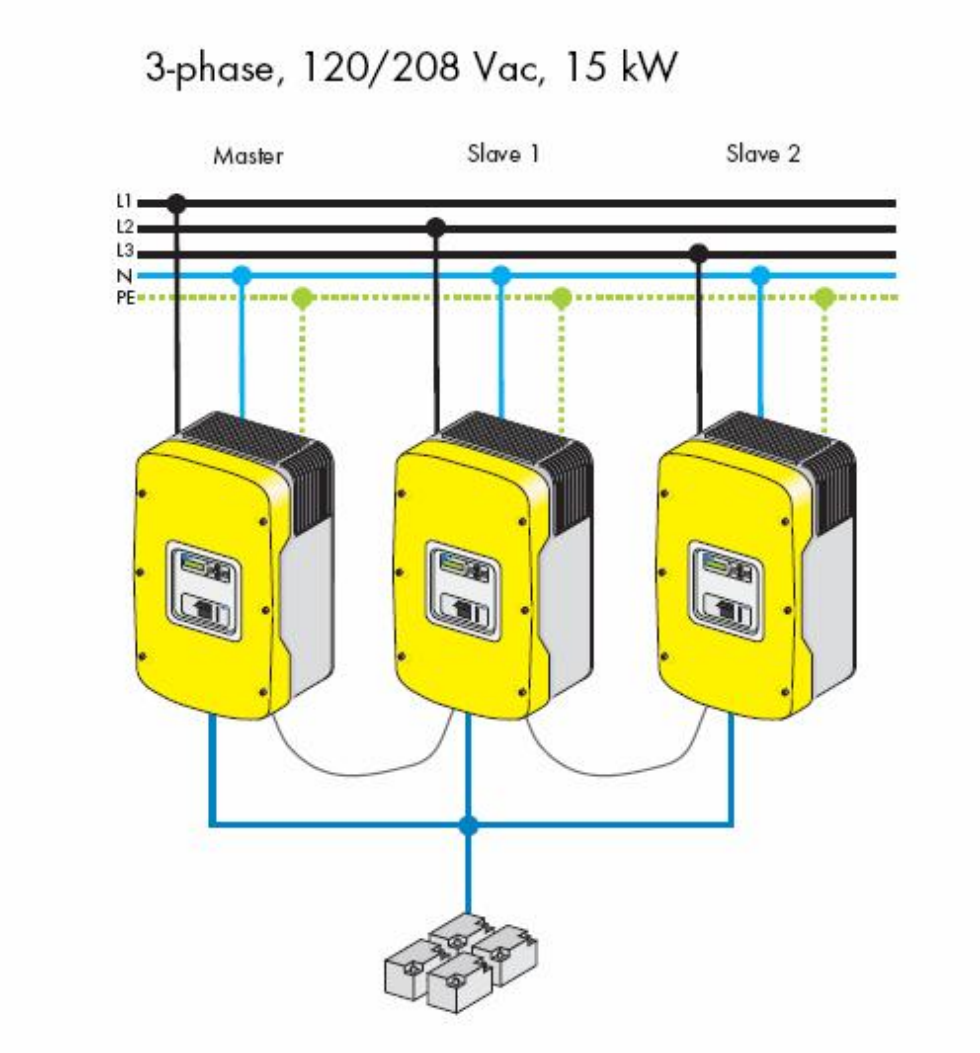


One Master and one to 4 slaves

Dual Split Phase (Single Phase 240)

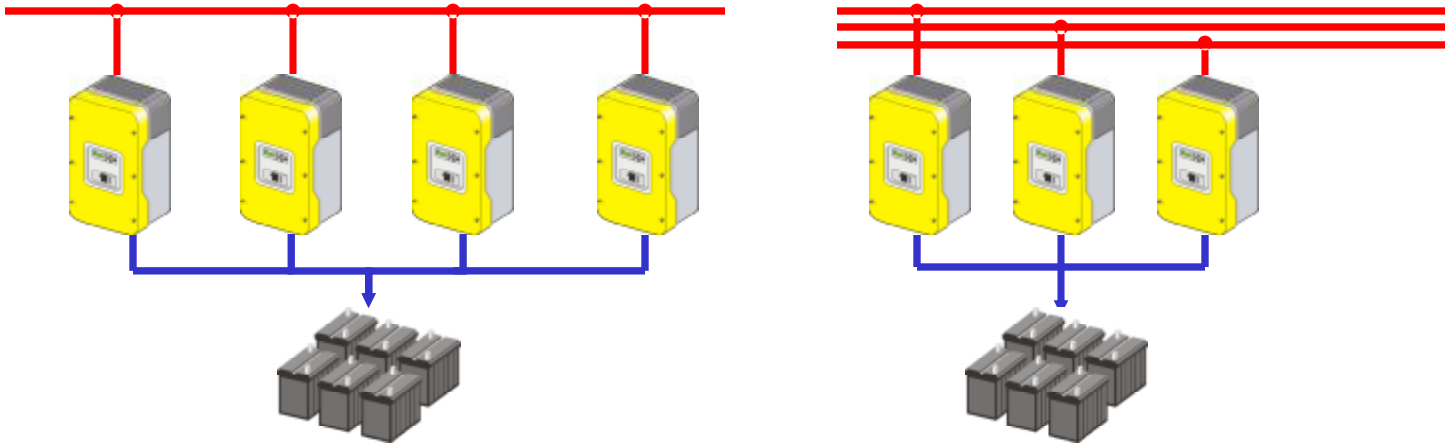


Three Phase

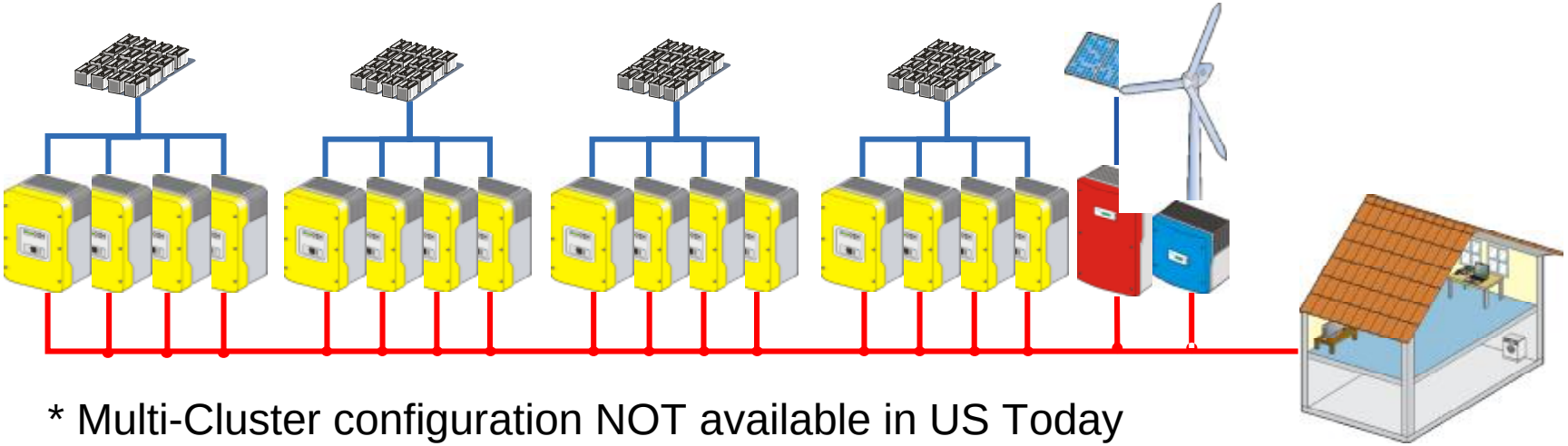


Definition – Cluster / Mulit-cluster (SI Collective)

- Cluster = Several Sunny Islands, One Battery, Common Load

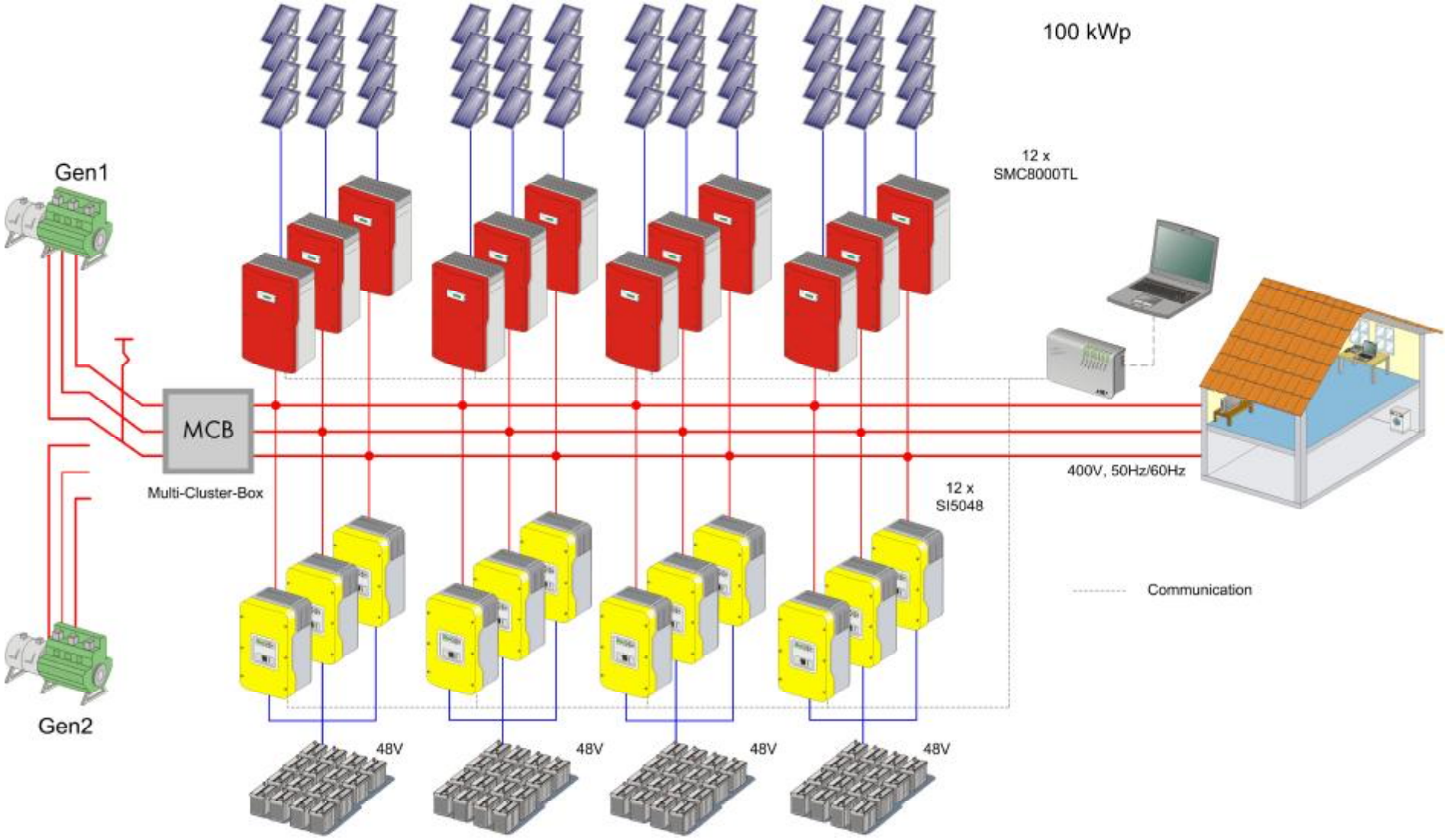


- * Multi-cluster = Several Clusters in parallel operation (SI Collective)



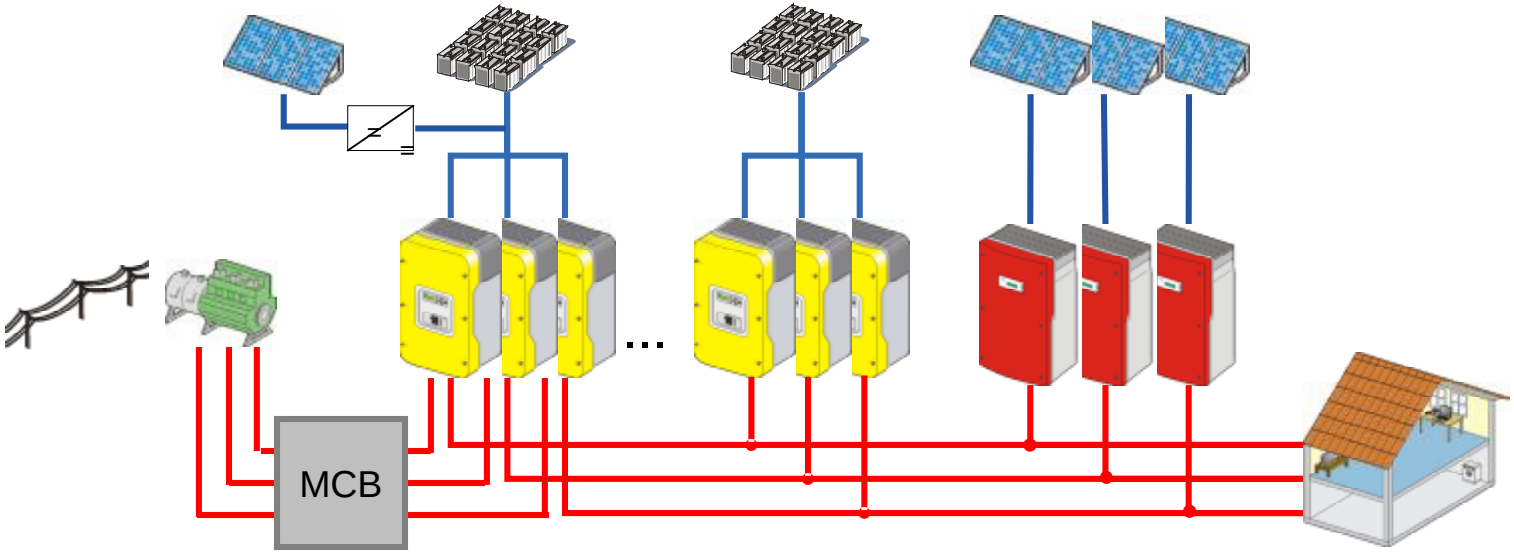
* Multi-Cluster configuration NOT available in US Today

Planned village power supply (78kW)



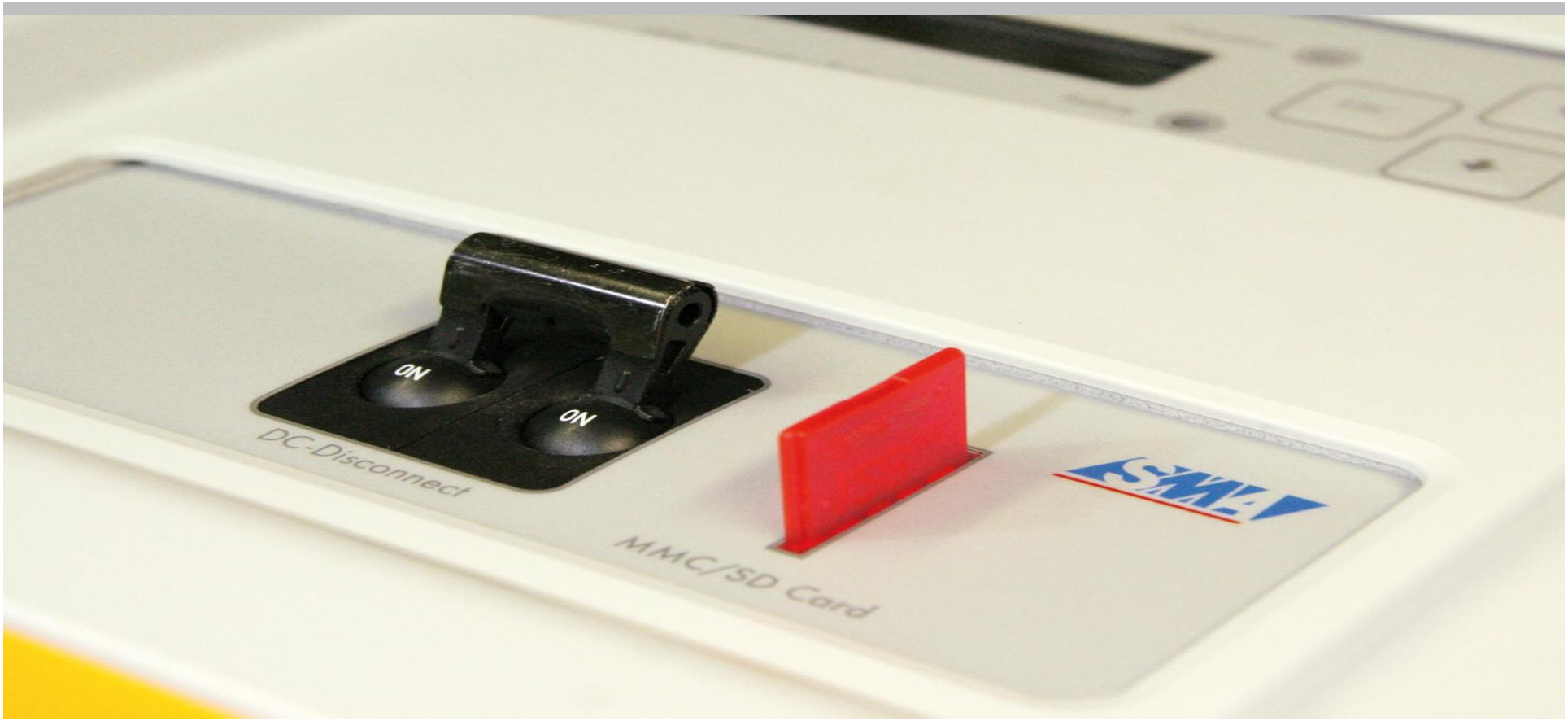
System Design - Conclusions

- **Highest Flexibility**
  - AC and/or DC coupled systems are possible
  - Single phase, split phase, and three phase configurations
  - Interactive operation with generator and/or public grid
  - For Off-Grid Systems up to 20 kW per cluster in (Single- or Split phase), 15 kW per cluster in 3 Phase
  - Larger systems possible in future with multi-cluster box (MCB)



Multi-Cluster-Box

Configuring Sunny Island 5048U



Quick Start Guide – Several Options

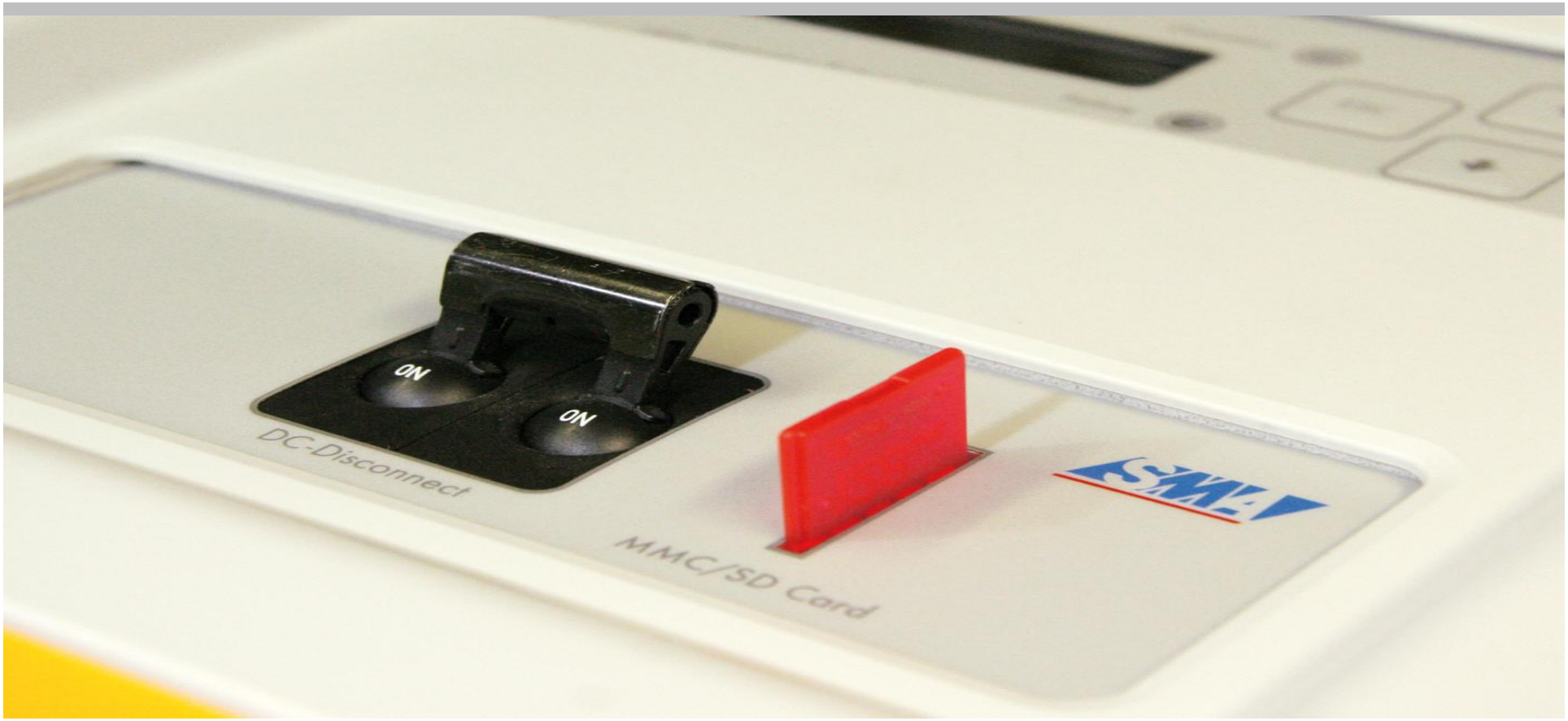
- **"Start System"** (if you have accidentally accessed the QCG and only would like to restart the system)
- **"New System"** (if you would like to start a new system or perform changes to the system configuration) –
- **"New Battery"** (if you would like to change the main battery settings, but retain the system configuration) –
- **"Emerg Charge"** (if you would like to charge a deeply discharged battery using an external source

New System

- Quick Configuration Guide
  - Only 6 steps for initial startup of the system
    1. **System Configuration (See Overview Table)**
    2. **Device Configuration (Master or Slave#)**
       a. **Slave configuration stops here.**
    3. **Date and Time**
    4. **Battery (type and capacity)**
    5. **Nominal voltage (see below)**
    6. **Maximum generator current and generator interface**

- Change of system voltage (DC) in case of failed battery cells
  - 48V, 46V, 44V, 42V adjustable
  - Over all, 3 cells can quit working

5048U System Management



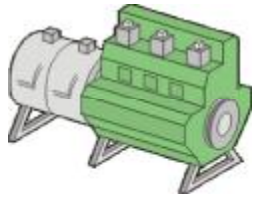
Sunny Island – System Management

- System Management
  - Control of other Sunny Islands
  - Connection to additional sources
  - Regulation and control of energy sources
  - Programmable relay controls

- Battery Management
  - Efficient battery charge and discharge
  - Sophisticated charge control algorithms prolong service life
  - b
- Load Management
  - Connection and disconnection of loads
    - Based on battery SOC, time of day, load level, etc.
  - Overload capability for motor starting

System Management Functions

- Power Control of other AC-Energy Sources
  - (Sunny Boy, Windy Boy, Generator)



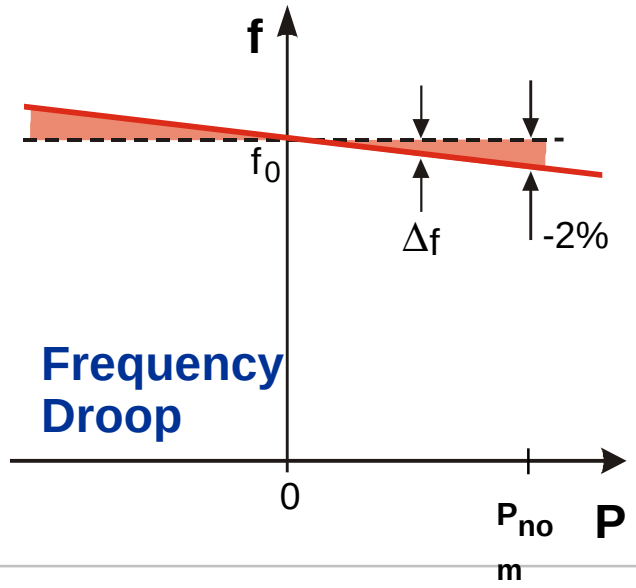
- Automatic start and stop of generators
  - SOC dependent
  - Load dependent
  - Time dependant

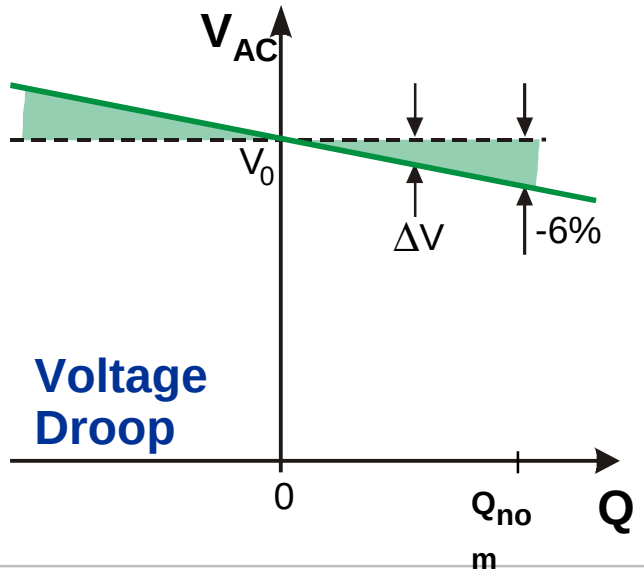
- Load shedding
  - SOC dependent
  - Load dependent

- Load dependent control of other Sunny Islands
  - (Sleep-Mode)

Power management - Droop Mode

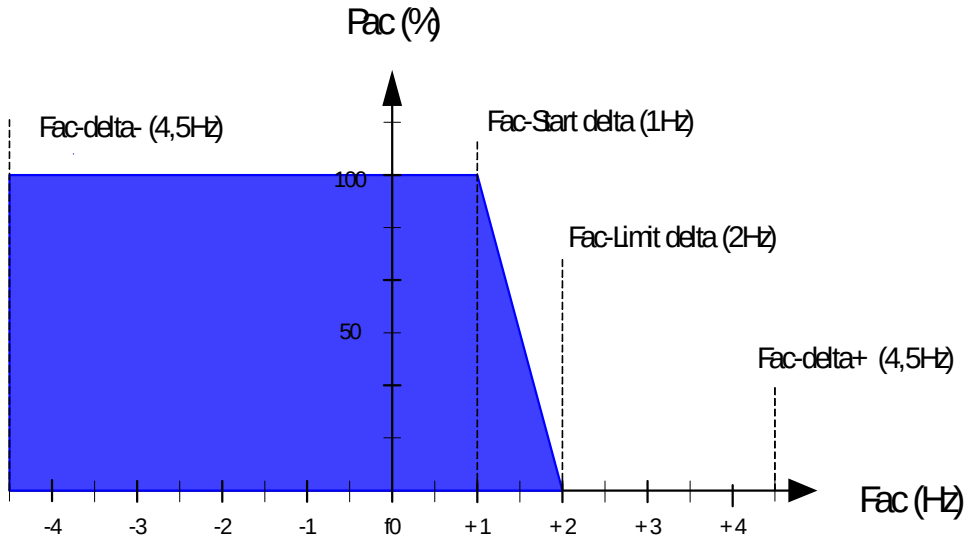
- Parallel operation of multiple battery inverters with diesel generators and/or public grid
- Based on P/f - and Q/V-Statics of energy sources (analogous to conventional public power supplies)
- Statistics are implemented within S*unny Island*® battery inverters





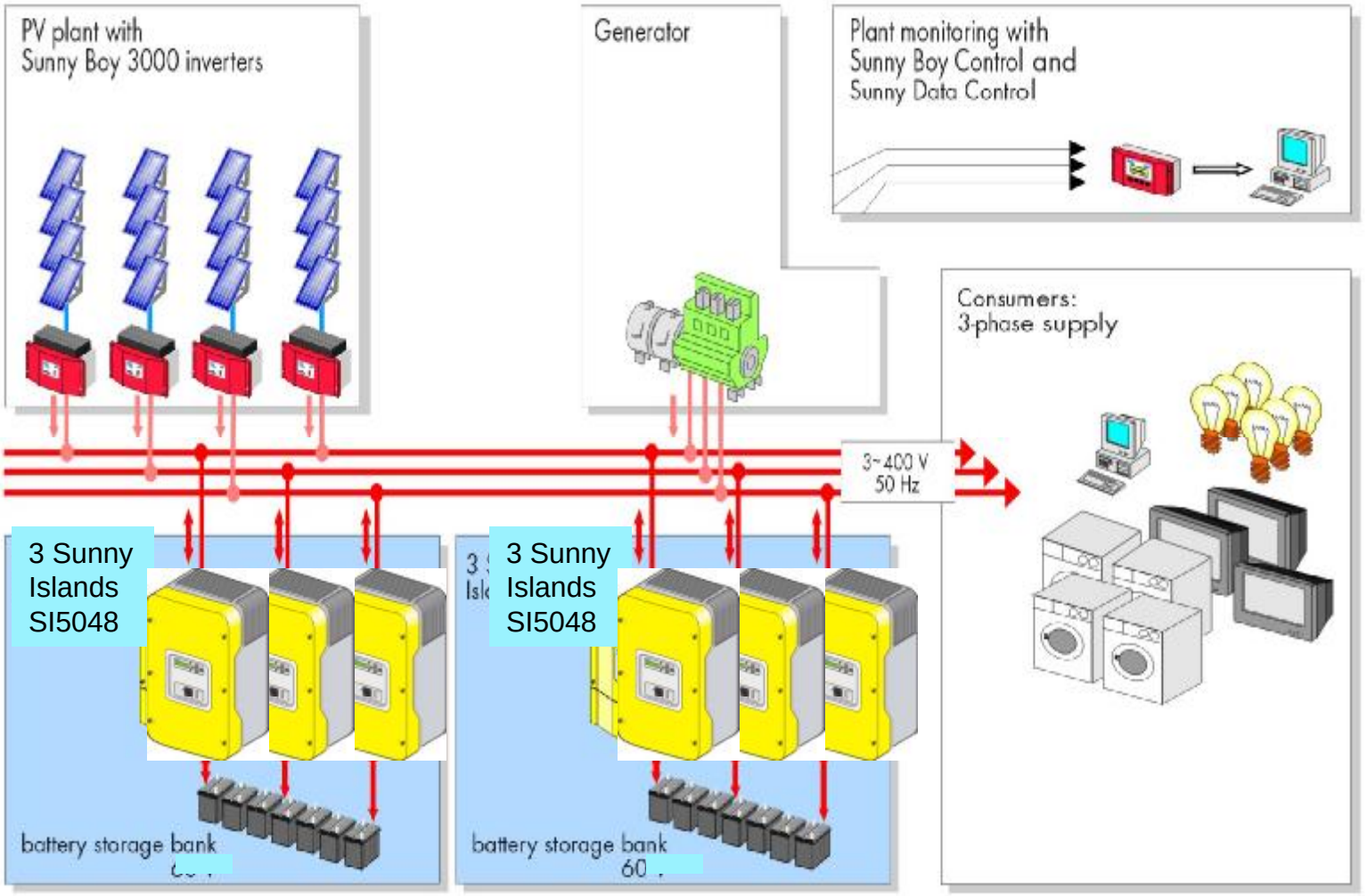
Power control of Sunny Boys

- Frequency Shift Power Control



  - No additional communication necessary
  - A rising grid frequency lowers the energy output of the Sunny Boys

Examples for usage of Droop-Mode



Relay control

- Relay control by Sunny Island 5048
  - 2 integrated relays in each inverter
  - Functions are selectable for each relay
  - More than 15 different functions available today
    - Other functions can be added as needed by market
  - More Sunny islands equals more functions (4x Sunny Island within a Cluster = 8 Relays)
  - Relays have common, NO & NC connections

Relay control functions SI5048U

- SOC dependent (in %)
  - At what SOC does the relay close
  - At what SOC the relay open
  - What is time of day ?
    - 2 independent time periods with programmable SOC limits

- Power dependent (in kW and minutes)
  - At what power does the relay close
  - How long has the power been above the limit before activated
  - At what power does the relay open
  - How long has the power been below the limit before deactivated

Other Relay Control Functions

- Time dependent (Timer based)
  - 2 independent timers
  - Cyclic usage (every day at 10:00 / every Friday)
  - Usage of date and time (on 12.04.2009)
  - Usage of a running time (01:20:45)

- Other functions
  - Close/open while in absorption phase
  - Close/open when a warning or failure occurs
  - Close/open while Sunny Island is in operation
  - Close/open while the generator is in operation
  - Close/open while the grid is present
  - Control of battery room fan
  - Control of battery bubbler (electrolyte circulation pump)

System management – System security

- Silent Mode
  - Operation grid tied as backup system
  - Battery is fully charged
  - Loads are completely supplied by grid
- Benefits:
  - Stops switching operation
  - Lowers SI internal power consumption (25 Watts >> 4 Watts)
  - Still transfers loads seamlessly in case of a grid failure
  - Reduces energy needed to keep batteries charged
  - Switches to float charge periodically to keep battery at high SOC
  - Protects batteries against over charging

System management – System security

- Short circuit detection
  - Short circuit in Off-Grid system or in an external source
  - Current limit is five times the nominal current
  - Disconnection of external sources within 20ms
  - Carrying of a short circuit current (120 Amps AC) for 100ms
  - Allows tripping of over current devices

Overview of Safety Features

- DC reverse polarity protection, short circuit safe
- Integrated DC breaker
- AC current limitation for generator / grid
- Over and under voltage detection AC/DC
- Over and under AC frequency
- Temperature compensated battery charging
- High battery temperature shut down
- Reactive power compensation of the generator
- Generator Relay failure detection
- Generator: Reverse Power Detection
- Over temperature protection

Battery Management System

- Battery types
  - FLA: Flooded Lead Acid
  - VRLA: Valve Regulated Lead Acid
  - NiCd: Nickel Cadmium/Nickel Iron
- Battery capacities
  - Capacity range: 100 – 10,000 Ah
  - Adjustable battery voltages:

    48V, 46V, 44V, 42V
- Accurate evaluation of State-of-Charge
  - Adaptive algorithm learns over time
  - Based on Voltage, Current, and cycle history

BMS Description “State-of-Charge“

- The “State of Charge“ (SOC) describes the amount of energy contained in the battery as a percentage of it’s capacity

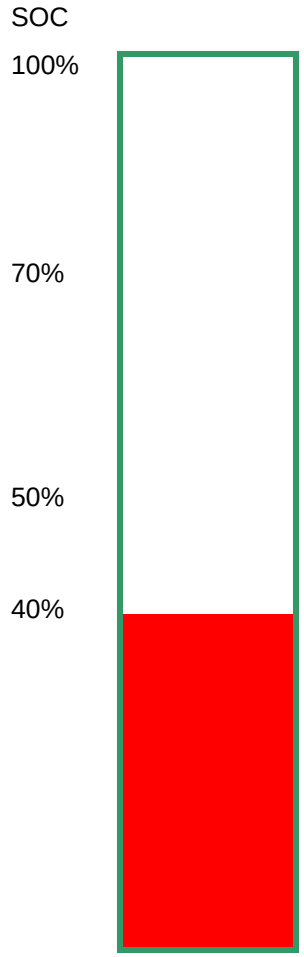
- If there was a battery with a capacity of 100 Ah and there is 70 Ah of energy remaining in this battery, the SOC is 70%.

- In Sunny Island systems the SOC represents a central value, which is decisive for almost every switching operation within a system.

Generator start and load shedding by SOC

4 different battery states

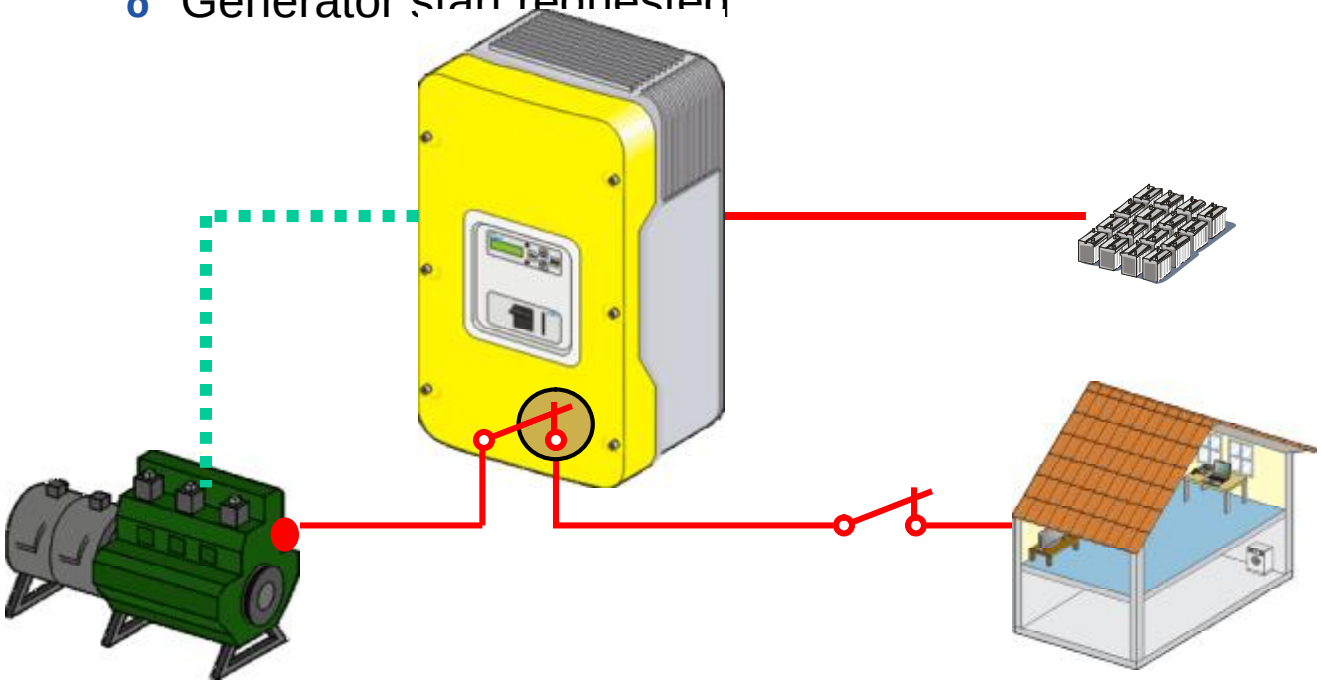
- Normal (Normal)
- Battery “Low“ (Warning)
- Battery discharged (Low)
- Battery deeply discharged (Critical)

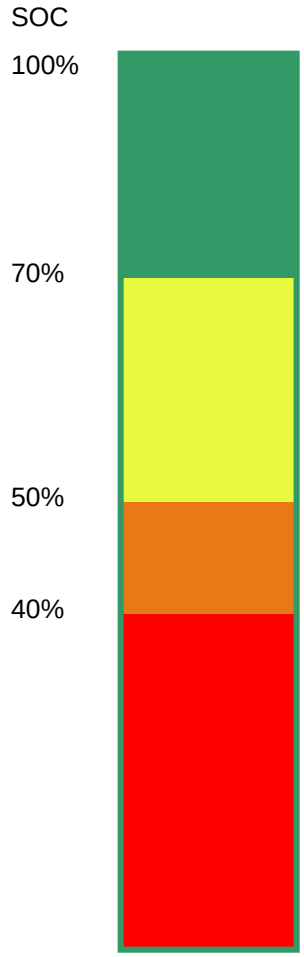


Note: No real SOC is being calculated. The SOC is being approximated out of the current-voltage curve.

Adjustable battery SOC limits –1

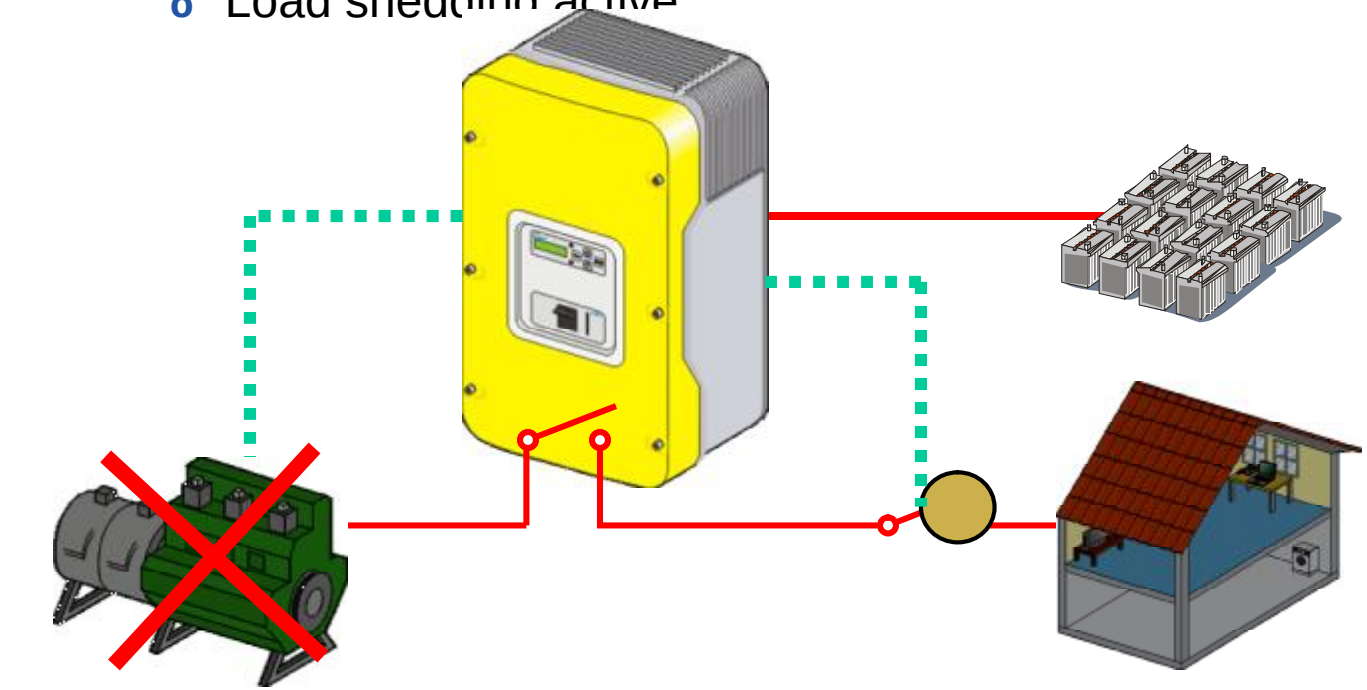
- SocLim1 – State-of-Charge Limit 1
  - Value in %, e.g. 70%
- Normal >> Warning
  - Generator start requested



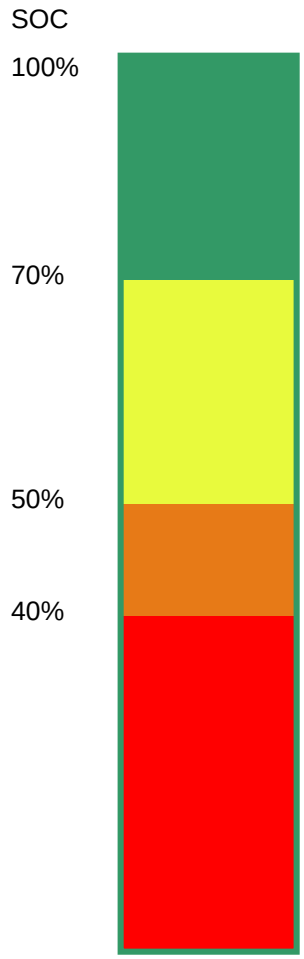


Adjustable battery SOC Limits - 2

- SocLim2 – State-of-Charge Limit 2
  - Value in %, e.g. 50%
- Warning >> Low
  - Load shedding active

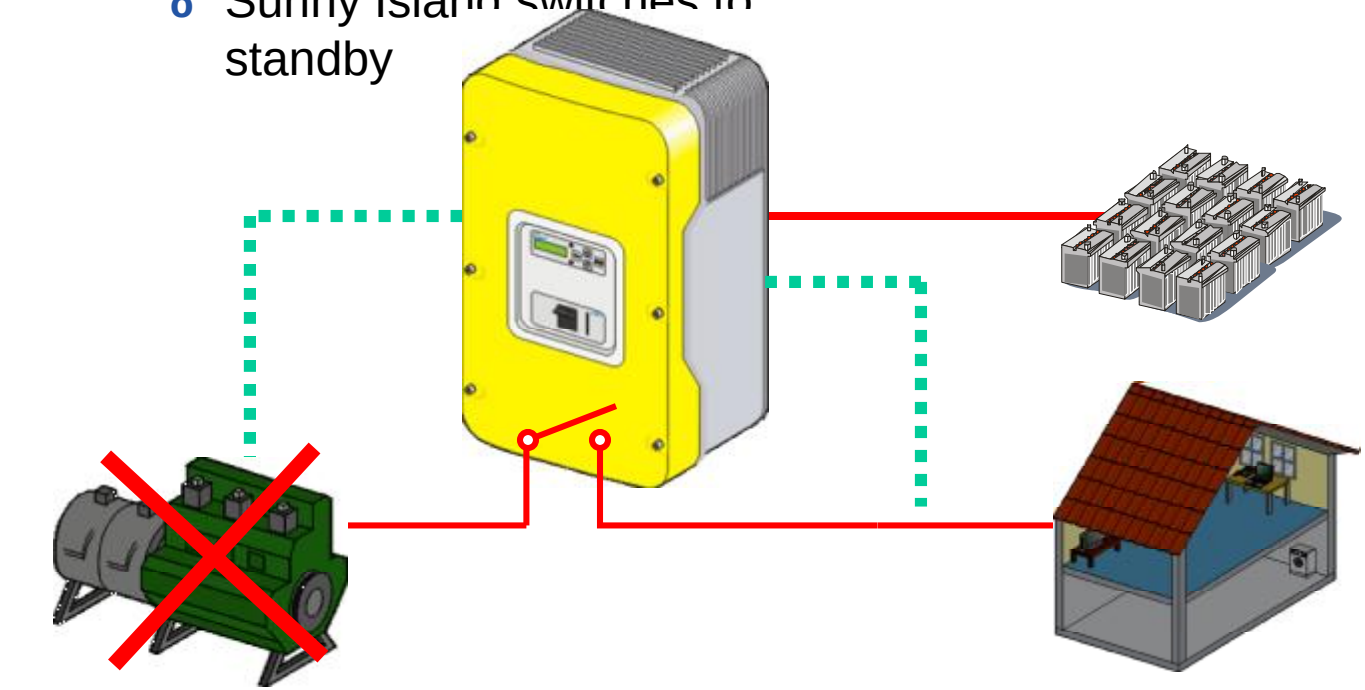


Generator Failure !

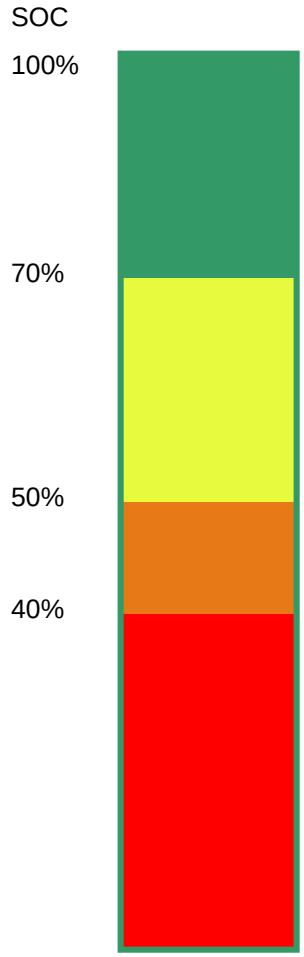


Adjustable battery SOC Limits - 3

- SocLim3 – State-of-Charge Limit 3
  - Value in %, e.g. 40%
- Low >> Critical
  - Sunny Island switches to standby

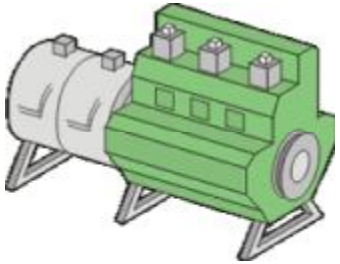


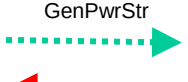
Generator Failure !

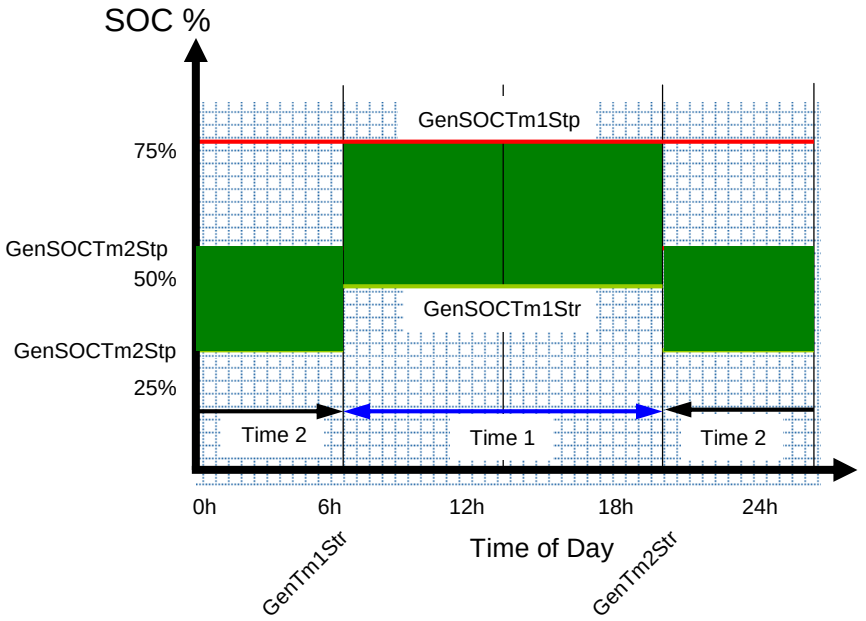


Time dependant SOC generator control

- Two time periods with independent SOC levels can be defined
  - Lower generator start SOC can be specified to prevent generator operation during night time hours, i.e. “quiet time”
  - Still allows generator start request if battery becomes critically low during “quiet time”
- Additional time dependant generator run time or load activation can also be scheduled using other programmable relay options on a daily or weekly schedule

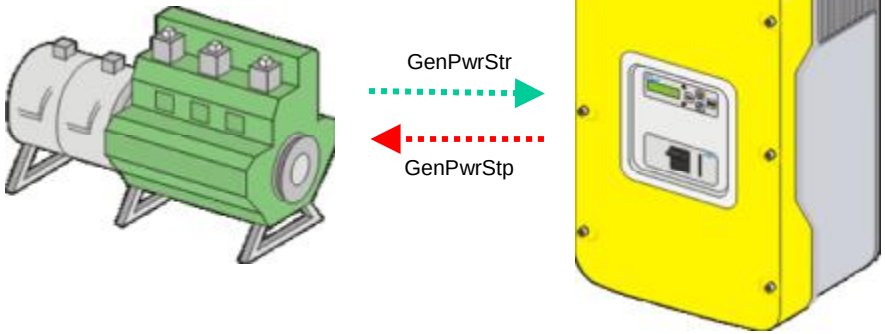


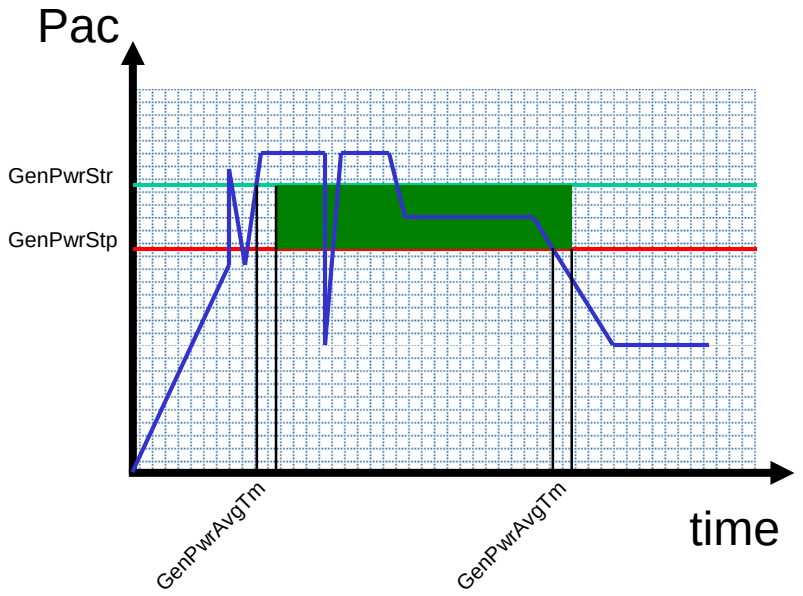




Load dependent generator control

- When load power exceeds the programmable Generator Power Start (GenPwrStr) level the generator will be requested
- The generator continues to run as long as load power stay above the programmable Generator Power Stop (GenPwrStp) level, or for the minimum generator running time, whichever is greater.
- Both Start and Stop commands require the power to be outside the limits for a programmable time period (GenPwrAvgTm) to avoid starting or stopping due to transient conditions





Batteries in Sunny Island Systems

General Questions on Batteries

- What is application ?
  - Off grid or grid backup
- What is the electrical load on the system ?
  - Are some loads non-critical
- How large is the PV array ?
- Are other energy sources present ?
  - Generator
  - Wind Turbine
  - Hydro turbine
- Sizing off grid systems

Objectives of the Battery Management System (BMS)

- High availability and safety of operation by
  - Disconnection in case of over temperature
  - Disconnection in case of exhaustive discharge
  - Disconnection in case of overcharge
- Long battery service life by
  - Automatic full and equalizing charge
    - Doubling of service life
  - Prevention of exhaustive discharge by SOC monitoring
    - utilization of battery capacity increased by 30%
- Exact SOC determination for user and operational control
  - SI 5048 has an integrated SOC calculation

Functions of the Battery Management

- Monitoring of the limit values
- Calculation of capacity
- Discharge monitoring / limiting
- Control of battery charging
- Display of the state of charge (SOC)

Battery Management: SOC Determination

- Not Possible:
  - Direct measurement of SOC
- Possible:
  - Mathematic modeling and calculation
  - Complex algorithms are required
- Many different variables affect an exact determination
- Battery, history, age, temperature, discharging current, etc. affect the amount of energy available within the battery

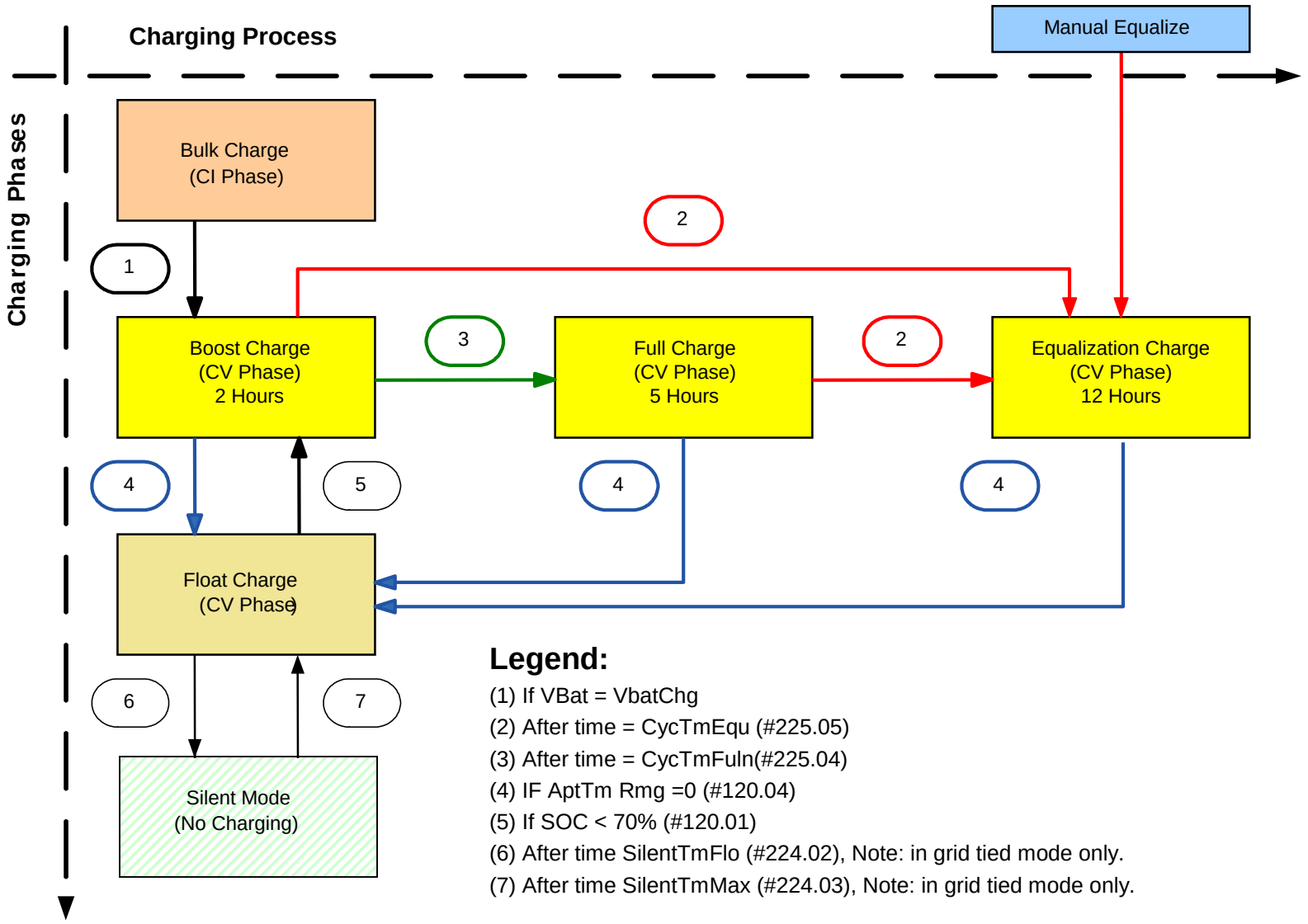
SOC determination in the Sunny Island:

Combination of Ah accumulation and self-adapting current/voltage model

Charge Modes

- Boost Charge
  - High voltage, short term
    - SOC of 85 .. 95% SOC
- Full Charge
  - Medium voltage, medium term
    - SOC of 92 .. 97%
- Equalizing Charge
  - Medium voltage, long term
    - SOC of 95 .. 100%
- Float Charge
  - Maintaining of battery voltage and state of charge
    - Maintaining SOC of 95 .. 100%
- Silent Mode
  - Prevention of current flowing into and out of the battery
    - SOC can be reduced (depending on battery type)

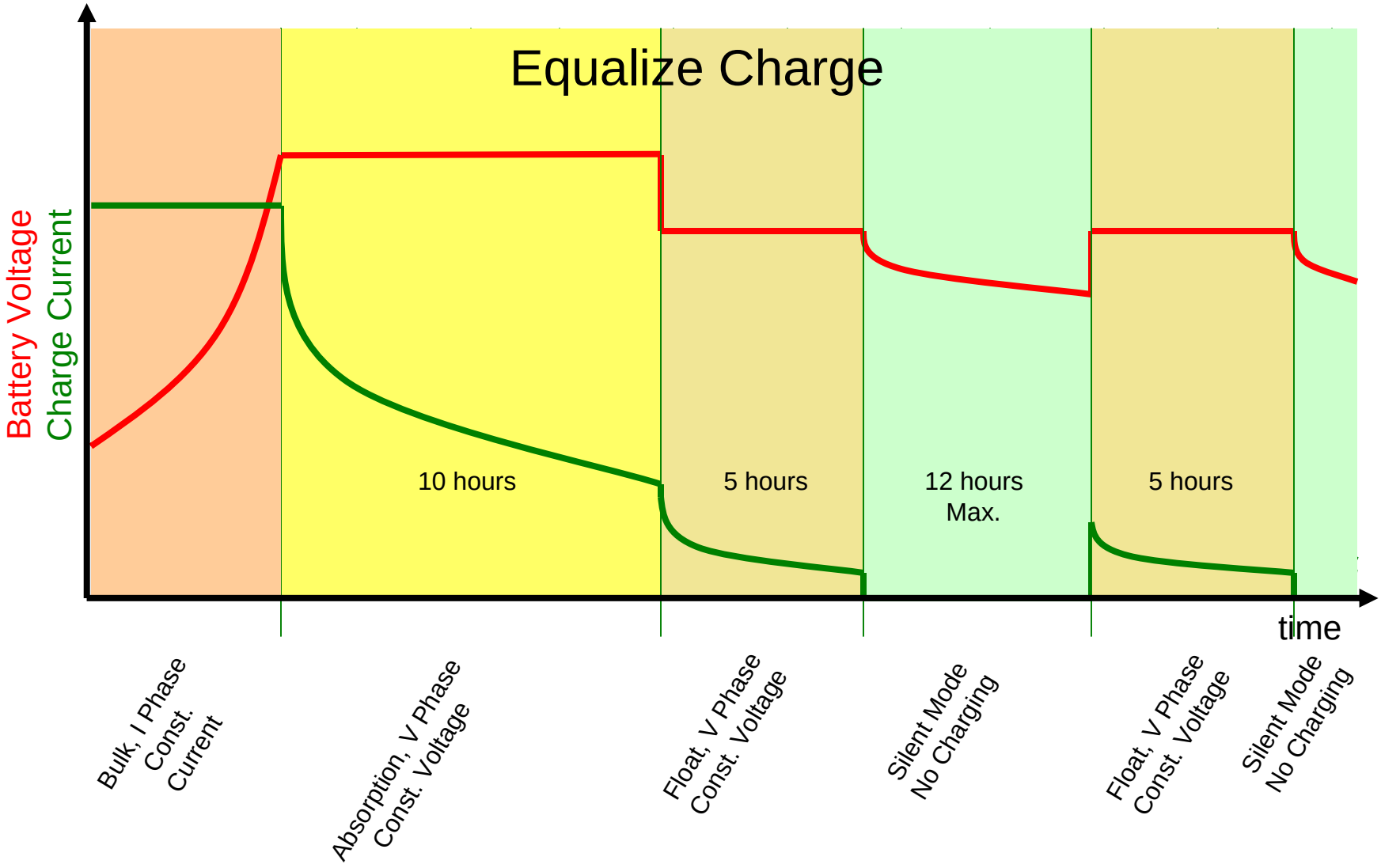
Battery Management System



Legend:

(1) If VBat = VbatChg
(2) After time = CycTmEqu (#225.05)
(3) After time = CycTmFuln(#225.04)
(4) IF AptTm Rmg =0 (#120.04)
(5) If SOC < 70% (#120.01)
(6) After time SilentTmFlo (#224.02), Note: in grid tied mode only.
(7) After time SilentTmMax (#224.03), Note: in grid tied mode only.

Sunny Island Charging Process



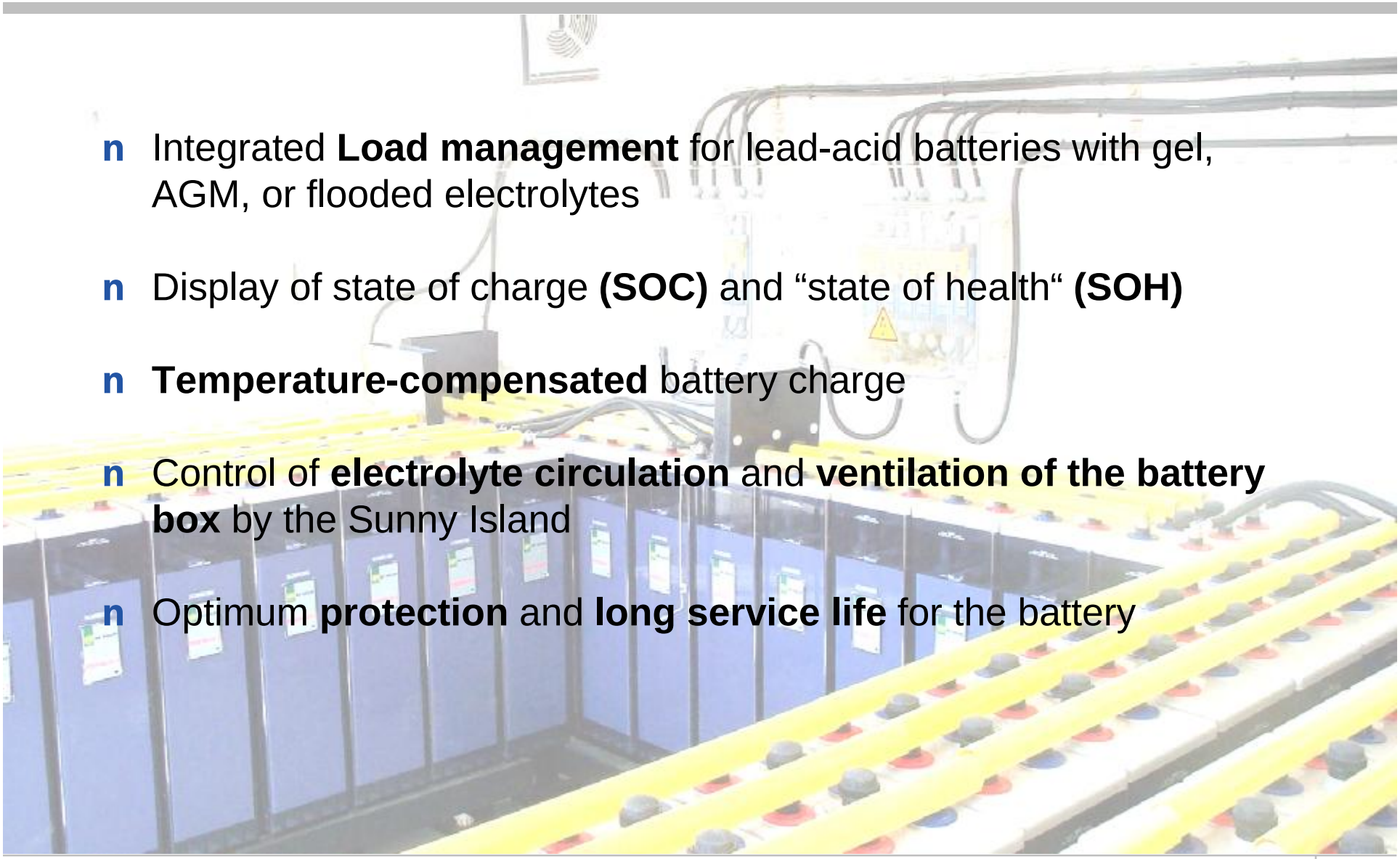
Simple Configuration of the BMS

Parameters:

- Battery type
  - FLA: **F**looded **L**ead **A**cid (liquid electrolyte)
  - VRLA: **V**alve **R**egulated **L**ead **A**cid (defined electrolyte lead-gel and ???fleece batteries AGM)
  - NiCd: **Ni**ckel-**Ca**dmium
- Nominal battery voltage
  - FLA/VRLA: **48 V** (48 .. 42 V)
  - NiCd: **45.6 V** (48 .. 43,2 V)
- Battery capacity
  - **100 Ah** (100Ah .. 10.000 Ah)

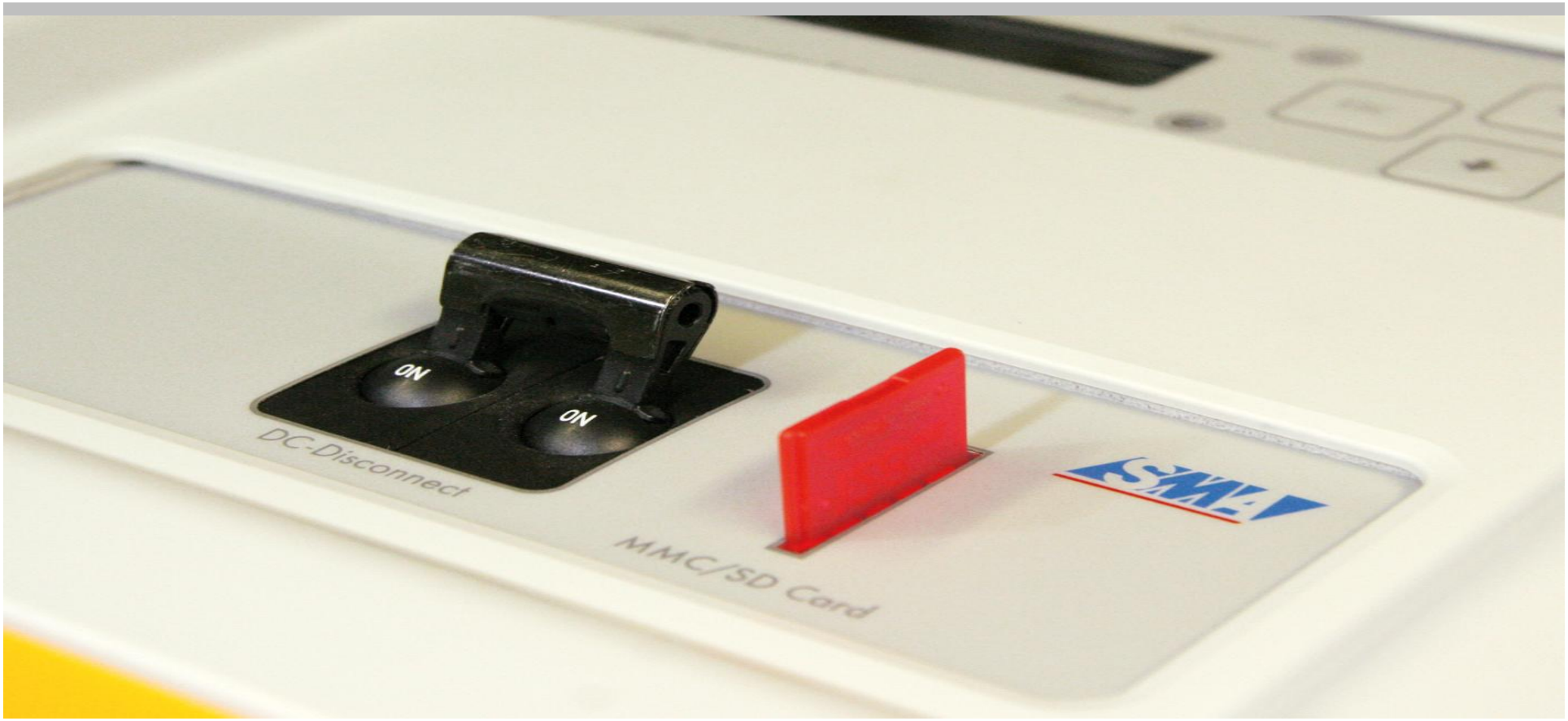
Ø All other values are correctly set automatically

Optimum Protection for the Battery



- Integrated **Load management** for lead-acid batteries with gel, AGM, or flooded electrolytes
- Display of state of charge **(SOC)** and “state of health“ **(SOH)**
- **Temperature-compensated** battery charge
- Control of **electrolyte circulation** and **ventilation of the battery box** by the Sunny Island
- Optimum **protection** and **long service life** for the battery

Sunny Island 5048U
Generators and GMS



Generators – Lots of Choices

- Fixed or mobile
- Diesel, bio-diesel, gasoline, propane, or natural gas
- With or without enclosure
- With or without sound absorption
- From 0.6 kW to 50 MW
- With or without simultaneous use of heat (CHP)
- 1800 RPM or 3600 RPM
  - 1800 RPM – Off Grid
  - 3600 RPM – Backup Power

Grid-Forming Generators

Grid-forming

Generator is functioning as voltage source

Advantages and Disadvantages

- **C** Backup supply of loads is possible
- **D** Parallel operation of several units is very complex

What types are these ?

- Ø All backup style generators
- Ø All synchronous generators
- Ø Most with asynchronous generators (excitation via capacitors)

Operation with Sunny Island?

- **C** all

Supplementary Grid-Feeding Generators

Grid-feeding

Generator is functioning as current source

Advantages and Disadvantages

- **C** Simple parallel operation
- **D** Backup supply is not possible

What types are these ?

- Ø All generators identified as supplementary grid-feeding generators
- Ø Most of small combined heat and power (CHP) units

Operation with Sunny Island?

- **D** Senertec, Solo
- **C** Ecopower
- **C** Others in process

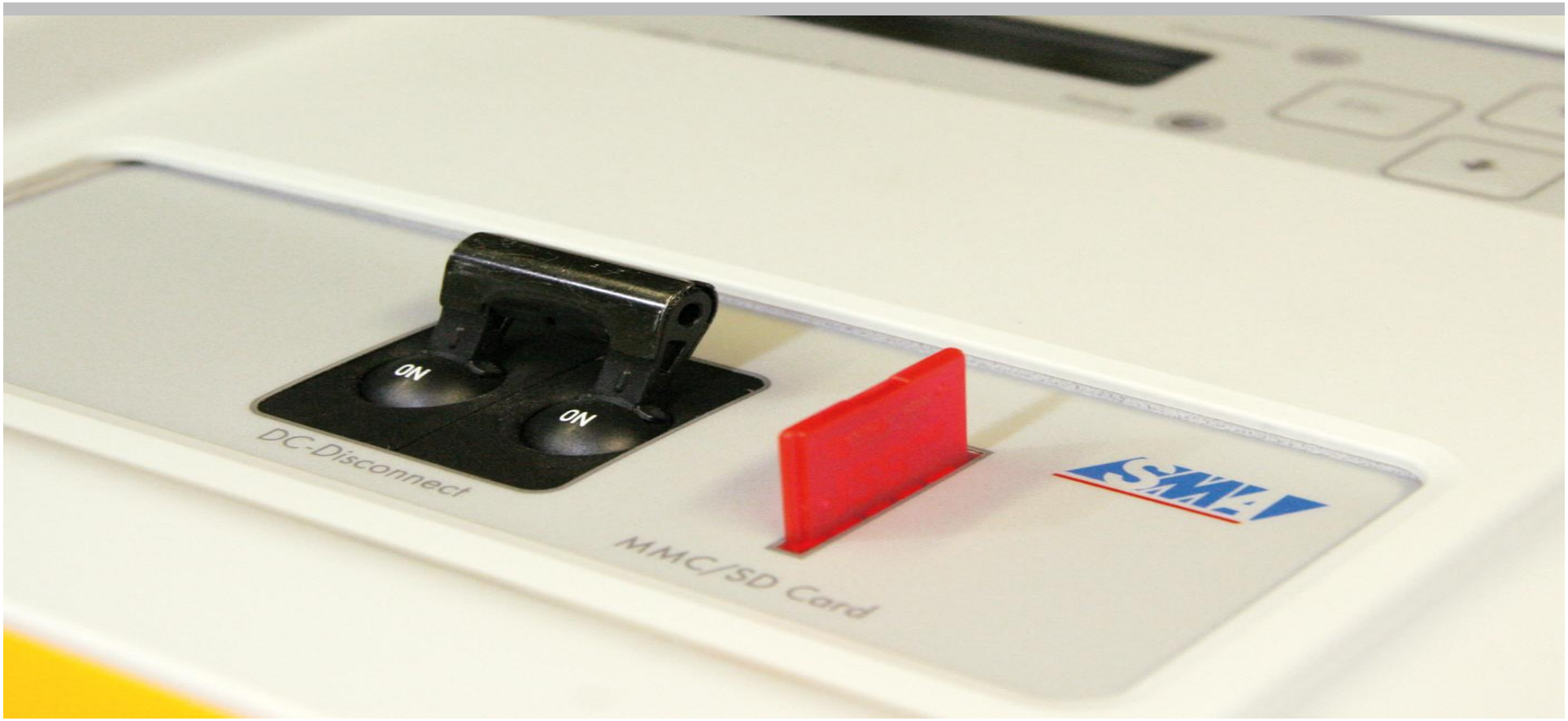
Generator Management

- Generator start:
  - Manual
  - State of charge (SOC)
  - Load
  - Time
- Generator control via:
  - Current
  - Frequency
  - Optimization of reactive power
- Generator support with full Sunny Island power
- Other Generator protective functions:
  - Adjustable warming-up time
  - Adjustable minimum operating time
  - Ramped generator loading
  - Run-on or cooling time

Generator Management

- Automatic or manual Start and Stop
  - Dry contact relay closure (NO, Com, NC)
  - Two wire type generators only
- Generator support (power addition)
  - Automatically reduces charging current to limit load on generator
  - Will discharge battery to support generator if needed
- Generator protection
  - Reverse power protection
  - Over / under voltage and frequency

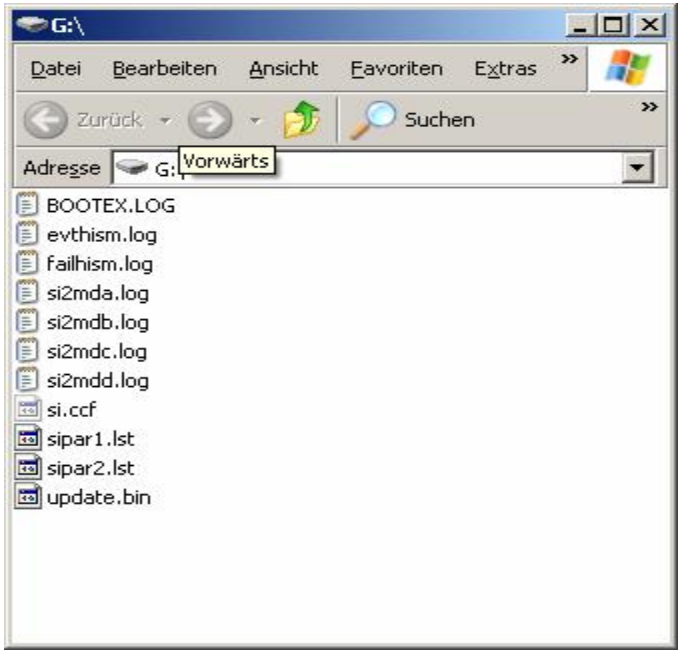
Sunny Island 5048U
Data Storage with SD Card



Application: Memory space for settings

- Saving of system settings (Parameter lists)
  - Backup for user after incorrect settings
  - Backup of all data for the installer
  - Automatic re-importing of parameters after software update
  - 2 different parameter sets can be stored

- Customized parameter lists by mail
  - Typical system settings can be mailed or emailed easily
  - Possible settings don‘t have to be set at the unit.
  - Can be programmed and sent by installer or SMA



SD Card Files – Parameter Lists

- Three separate parameter lists can be used
  - Factory default settings are used when system is initialized or re-initialized
  - Two additional parameter lists can be stored or loaded
  - File names: SIPAR1.LST and SIPAR2.LST
- Parameter Lists should be stored before and after making changes to system
  - Allows return to old settings if changes resulted in undesirable operation
  - If parameters were accidentally changed
- Proven or “favorite” parameter sets can be stored on SD cards and carried from job to job to speed up programming
- Parameters can be edited using PC and stored on SD card
- Parameter lists are invaluable when troubleshooting system

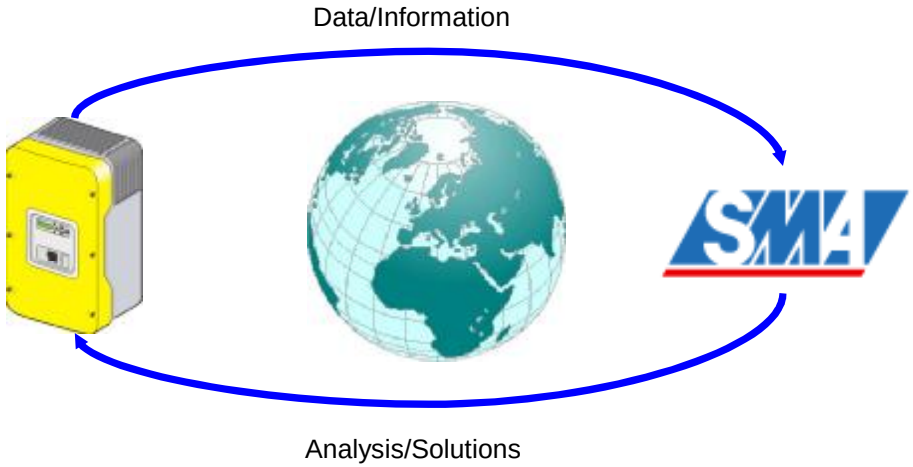
Application: Firmware-Update

- Automatic updating of firmware via SD/MMC card
  - SI automatically detects firmware version
  - Master automatically self updates
  - Master automatically updates slave units

- Manual “downgrading” of firmware is possible if needed
  - Master automatically downgrades Slave firmware

- Convenient updating of operating firmware
  - Easy mailing of firmware via Internet or “snail mail”
  - Download of firmware via SMA websites in future
  - Firmware / parameters can be updated by untrained users
    - No service personnel needed
    - No complicated hardware exchange necessary
    - “Just insert the SD card”

Application: Service



- Saving all operating data in 1-minute-intervals
- Logging of events, warning, and failure codes with date & time
- Delivery of data via internet or “snail mail”
  - Very low shipping costs
  - Easy handling
  - Very fast analysis and help
  - Quickly resolve system problems

Using data to troubleshoot a system

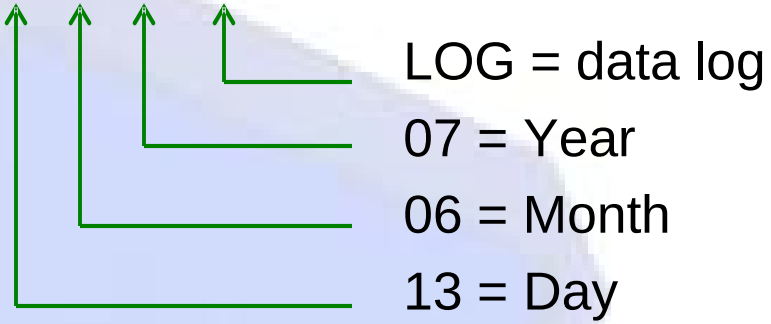
- EXAMPLE: Off Grid Beta Test System in Northern California

- System Configuration:
  - (2) SI5048U inverters in split phase
  - (2) SB1800U inverters with approx. 3.5 kW PV
  - Battery = 660 Ahrs @ 48 Vdc
  - 20 kW Generator (Propane)

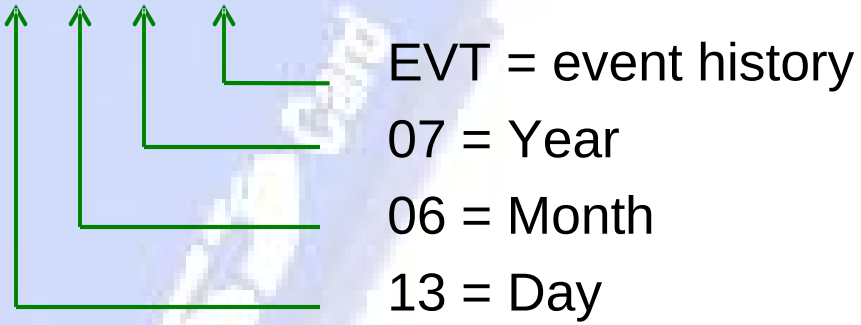
- Customer reported system shut down on June 13, 2007
  - System shut down in the morning
  - System was not charging batteries even with generator running
  - What happened ?

SD Card Files – Log and Event Files

- File Name - Log Files: SI130607.LOG



- File Name - Event Files: SI130607.EVT



- Event Files and Log files are generated daily
- Stored data is approximately 1 MB per day

Importing Data into Excel

- Make a copy of the data files stored on the SD card
  - Do not use original files to maintain data integrity !
- Open a blank worksheet in Excel
- Click on the Data Tab on the toolbar
  - Select import External Data, Import Data
- Find the sub-directory where the LOG and EVT files are stored
  - Choose “all files (*.*)” in the file type bar at the bottom of the page.
  - Click on the file of interest, e.g. SI130607.LOG
  - In the import wizard screen select “delimited” then click Next
  - Check the “tab” and “semicolon” boxes the click Next
  - Click Finish
  - Select the cell where the data will be place, e.g. A1
    - Note: when adding multiple days choose a cell below the last day imported, e.g. A1402

Example of Log File

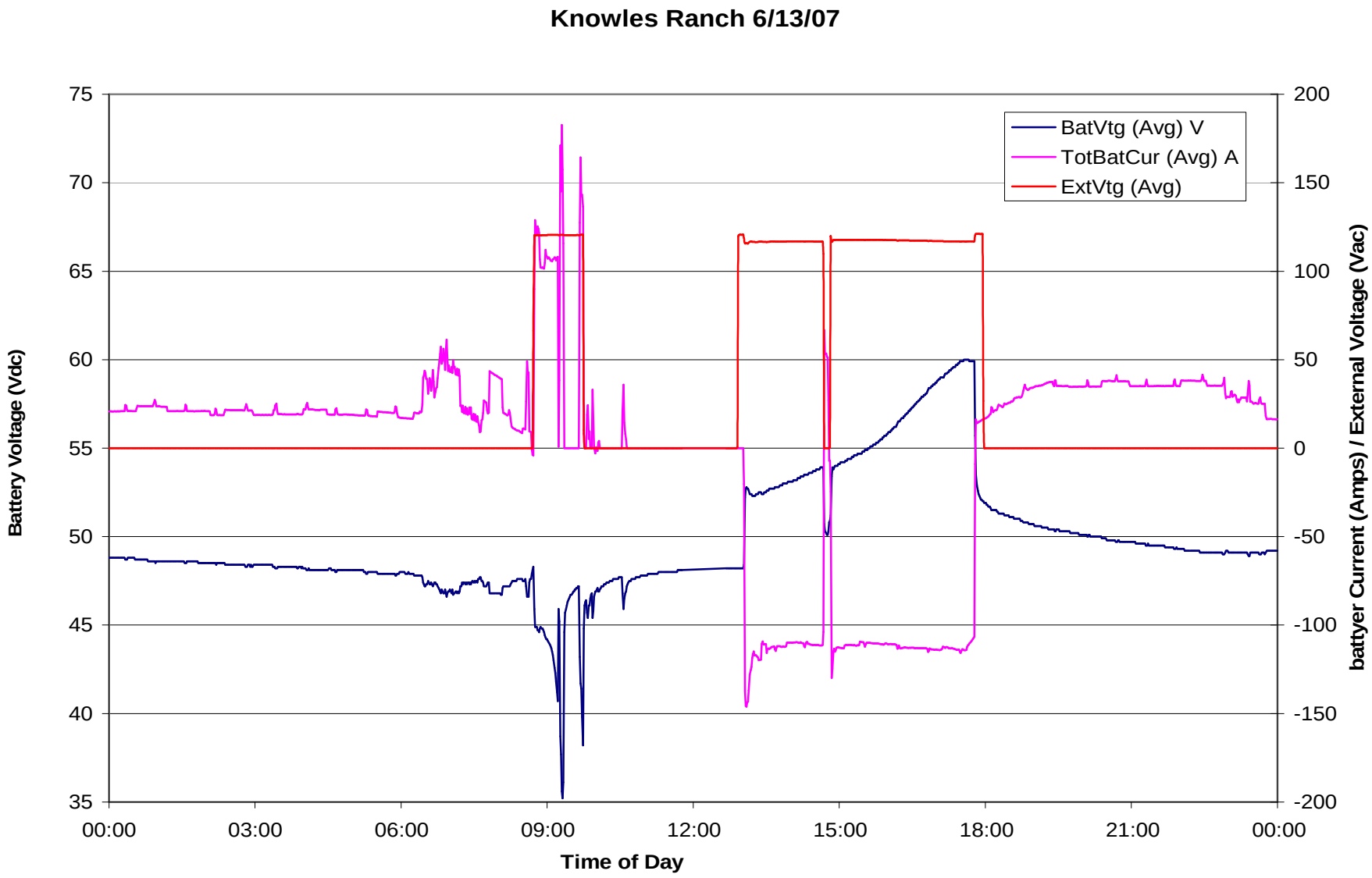
```
##################
#
#SI5048 - Log Data
#
##################
#
# SN  :  1260000196
# SN1 :  1260000234
# SN2 :          0
# SN3 :          0
#
```

TimeStamp	HsTmp (Max)	HsTmpSlv1 (Max)	HsTmpSlv2 (Max)	HsTmpSlv3 (Max)	TrfTmp (Max)	TrfTmpSlv1 (Max)	TrfTmpSlv2 (Max)	TrfTmpSlv3 (Max)	BatTmp (Max)	BatSoc (Avg)	Ba
DD.MM.YYYY hh:mm	degC	degC	degC	degC	degC	degC	degC	degC	degC	%	V
6/13/2007 00:00	35	31	0	0	47	43	0	0	25.4	66	
6/13/2007 00:01	35	31	0	0	47	43	0	0	25.4	66	
6/13/2007 00:02	35	31	0	0	47	43	0	0	25.4	66	
6/13/2007 00:03	35	31	0	0	47	44	0	0	25.4	66	
6/13/2007 00:04	35	31	0	0	47	44	0	0	25.4	66	
6/13/2007 00:05	35	31	0	0	47	44	0	0	25.4	66	
6/13/2007 00:06	35	31	0	0	47	43	0	0	25.4	66	
6/13/2007 00:07	34	31	0	0	47	43	0	0	25.4	66	
6/13/2007 00:08	35	31	0	0	47	43	0	0	25.4	66	
6/13/2007 00:09	35	31	0	0	47	43	0	0	25.4	66	
6/13/2007 00:10	35	31	0	0	47	43	0	0	25.4	66	
6/13/2007 00:11	34	31	0	0	47	43	0	0	25.4	65	
6/13/2007 00:12	34	31	0	0	47	43	0	0	25.4	65	
6/13/2007 00:13	34	31	0	0	47	43	0	0	25.4	65	
6/13/2007 00:14	34	31	0	0	47	43	0	0	25.4	65	
6/13/2007 00:15	34	31	0	0	47	43	0	0	25.4	65	
6/13/2007 00:16	35	31	0	0	47	43	0	0	25.2	65	
6/13/2007 00:17	35	31	0	0	47	43	0	0	25.2	65	
6/13/2007 00:18	34	31	0	0	47	43	0	0	25.2	65	
6/13/2007 00:19	34	31	0	0	47	43	0	0	25.2	65	
6/13/2007 00:20	34	31	0	0	47	43	0	0	25.2	65	
6/13/2007 00:21	34	31	0	0	47	43	0	0	25.2	65	
6/13/2007 00:22	34	31	0	0	47	43	0	0	25.2	65	
6/13/2007 00:23	35	31	0	0	47	43	0	0	25.2	65	
6/13/2007 00:24	35	31	0	0	47	43	0	0	25.2	65	
6/13/2007 00:25	34	31	0	0	47	43	0	0	25.2	65	

Parameters Stored in Log Files

TimeStamp
HsTmp (Max)
HsTmpSlv1 (Max)
HsTmpSlv2 (Max)
HsTmpSlv3 (Max)
TrfTmp (Max)
TrfTmpSlv1 (Max)
TrfTmpSlv2 (Max)
TrfTmpSlv3 (Max)
BatTmp (Max)
BatSoc (Avg)
BatVtg (Min)
BatVtg (Max)
BatVtg (Avg)
BatChrgVtg (Avg)
TotBatCur (Min)
TotBatCur (Max)
TotBatCur (Avg)
InvVtg (Min)
InvVtg (Max)
InvVtg (Avg)
InvVtgSlv1 (Min)
InvVtgSlv1 (Max)
InvVtgSlv1 (Avg)
InvVtgSlv2 (Min)
InvVtgSlv2 (Max)
InvVtgSlv2 (Avg)
InvFrq (Min)
InvFrq (Max)
InvFrq (Avg)
InvCur (Max)
InvCurSlv1 (Max)
InvCurSlv2 (Max)
InvCurSlv3 (Max)
InvPwrAt (Min)
InvPwrAt (Max)
InvPwrAt (Avg)
InvPwrAtSlv1 (Min)
InvPwrAtSlv1 (Max)
InvPwrAtSlv1 (Avg)
InvPwrAtSlv2 (Min)
InvPwrAtSlv2 (Max)
InvPwrAtSlv2 (Avg)
InvPwrAtSlv3 (Min)
InvPwrAtSlv3 (Max)
InvPwrAtSlv3 (Avg)
InvPwrRt (Min)
InvPwrRt (Max)
InvPwrRt (Avg)
InvPwrRtSlv1 (Min)
InvPwrRtSlv1 (Max)
InvPwrRtSlv1 (Avg)
InvPwrRtSlv2 (Min)
InvPwrRtSlv2 (Max)
InvPwrRtSlv2 (Avg)
InvPwrRtSlv3 (Min)
InvPwrRtSlv3 (Max)
InvPwrRtSlv3 (Avg)
ExtVtg (Min)
ExtVtg (Max)
ExtVtg (Avg)
ExtVtgSlv1 (Min)
ExtVtgSlv1 (Max)
ExtVtgSlv1 (Avg)
ExtVtgSlv2 (Min)
ExtVtgSlv2 (Max)
ExtVtgSlv2 (Avg)
ExtFrq (Min)
ExtFrq (Max)
ExtFrq (Avg)
ExtCur (Max)
ExtCurSlv1 (Max)
ExtCurSlv2 (Max)
ExtPwrAt (Min)
ExtPwrAt (Max)
ExtPwrAt (Avg)
ExtPwrAtSlv1 (Min)
ExtPwrAtSlv1 (Max)
ExtPwrAtSlv1 (Avg)
ExtPwrAtSlv2 (Min)
ExtPwrAtSlv2 (Max)
ExtPwrAtSlv2 (Avg)
ExtPwrRt (Min)
ExtPwrRt (Max)
ExtPwrRt (Avg)
ExtPwrRtSlv1 (Min)
ExtPwrRtSlv1 (Max)
ExtPwrRtSlv1 (Avg)
ExtPwrRtSlv2 (Min)
ExtPwrRtSlv2 (Max)
ExtPwrRtSlv2 (Avg)
GnStt
GnDmdSrc
Rly1Stt
Rly2Stt
BatChrgOp
OpStt
RmgTmEqu (Min)
RmgTmFul (Min)
AptTmRmg

Excel Chart of System on June 13, 2007

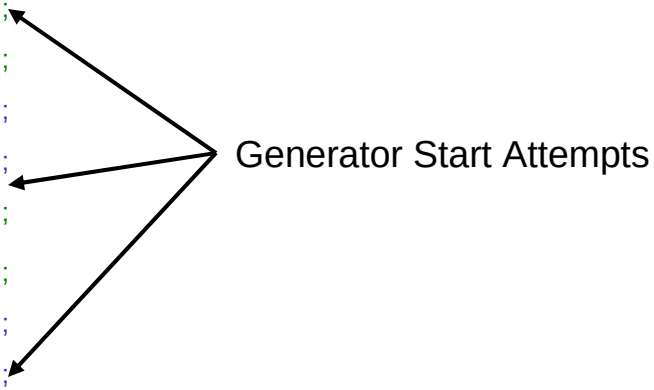


Example – Event File 1

```
##################
#
#SI5048 - Event/Failure History
#
##################
#
# SN  :  1260000196
# SN1 :  1260000234
# SN2 :          0
# SN3 :          0
#
TimeStamp;Type;Number;;
06/13/2007 04:33:29;E;401;;
06/13/2007 04:33:29;E;602;;
06/13/2007 04:37:29;E;402;;
06/13/2007 04:37:29;E;601;;
06/13/2007 04:42:29;E;401;;
06/13/2007 04:42:29;E;602;;
06/13/2007 04:46:29;E;402;;
06/13/2007 04:46:29;E;601;;
06/13/2007 04:51:29;E;401;;
06/13/2007 04:55:29;E;402;;
06/13/2007 04:55:29;E;601;;
06/13/2007 05:00:29;E;401;;
06/13/2007 05:00:29;E;602;;
06/13/2007 05:04:29;E;402;;
06/13/2007 05:04:29;E;601;;
06/13/2007 05:09:29;E;401;;
06/13/2007 05:09:29;E;602;;
06/13/2007 05:13:29;E;402;;
06/13/2007 05:13:29;E;601;;
06/13/2007 09:13:08;E;222;;
06/13/2007 09:13:08;E;101;;
06/13/2007 09:14:54;E;102;;
06/13/2007 09:14:55;E;103;;
06/13/2007 09:19:54;E;222;;
06/13/2007 09:19:54;E;101;;
06/13/2007 09:39:16;E;102;;
06/13/2007 09:39:18;E;103;;
06/13/2007 09:44:16;E;222;;
06/13/2007 09:44:16;E;101;;
06/13/2007 09:48:22;E;102;;
06/13/2007 09:48:24;E;103;;
06/13/2007 09:53:22;E;222;;
06/13/2007 09:53:22;E;101;;
06/13/2007 09:55:11;E;102;;
06/13/2007 09:55:13;E;103;;
06/13/2007 10:04:03;E;222;;
06/13/2007 10:04:03;E;101;;
06/13/2007 10:32:17;E;102;;
06/13/2007 10:32:19;E;103;;
06/13/2007 10:37:17;E;222;;
06/13/2007 10:37:17;E;101;;
06/13/2007 12:38:41;E;705;;
06/13/2007 12:38:42;E;402;;
06/13/2007 12:38:42;E;101;;
06/13/2007 12:38:43;E;204;;
06/13/2007 12:38:44;W;734;;
06/13/2007 12:38:44;E;711;;
06/13/2007 12:38:44;E;603;;
06/13/2007 12:38:45;E;619;;
06/13/2007 12:43:46;E;222;;
06/13/2007 13:01:44;E;102;;
06/13/2007 13:01:46;E;103;;
06/13/2007 13:02:22;E;610;;
06/13/2007 14:40:38;E;609;;
06/13/2007 14:43:38;E;402;;
06/13/2007 14:48:38;E;401;;
06/13/2007 14:48:38;E;602;;
06/13/2007 14:49:26;E;610;;
06/13/2007 14:49:26;E;104;;
06/13/2007 17:46:53;E;609;;
06/13/2007 17:51:53;E;402;;
06/13/2007 17:51:53;E;601;;
```

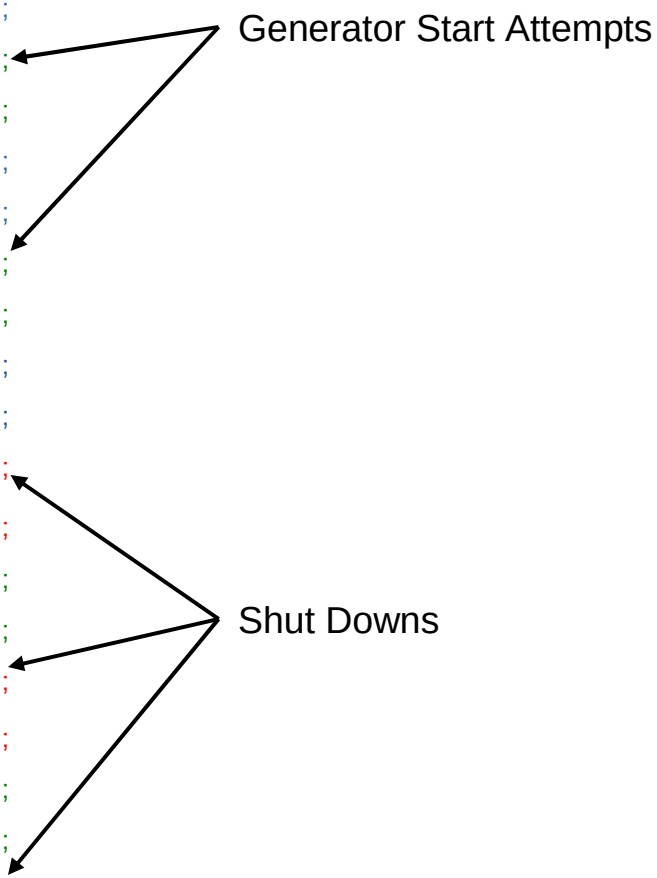
Example – Event File 2

```
##################
#
#SI5048 - Event/Failure History
#
##################
#
# SN  :  1260000196
# SN1 :  1260000234
# SN2 :          0
# SN3 :          0
#
TimeStamp;Type;Number;;
06/13/2007 04:33:29;E;401;;
06/13/2007 04:33:29;E;602;;
06/13/2007 04:37:29;E;402;;
06/13/2007 04:37:29;E;601;;
06/13/2007 04:42:29;E;401;;
06/13/2007 04:42:29;E;602;;
06/13/2007 04:46:29;E;402;;
06/13/2007 04:46:29;E;601;;
06/13/2007 04:51:29;E;401;;
```



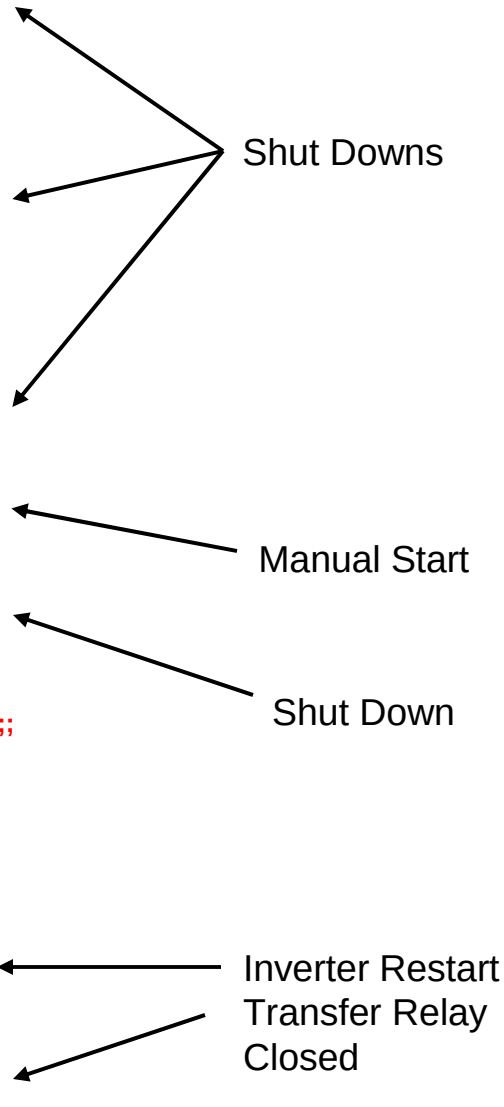
Example – Event File 3

```
##################
#
#SI5048 - Event/Failure History
#
##################
#
# SN  :  1260000196
# SN1 :  1260000234
# SN2 :          0
# SN3 :          0
#
TimeStamp;Type;Number;;
06/13/2007 04:33:29;E;401;;
06/13/2007 04:33:29;E;602;;
06/13/2007 04:37:29;E;402;;
06/13/2007 04:37:29;E;601;;
06/13/2007 04:42:29;E;401;;
06/13/2007 04:42:29;E;602;;
06/13/2007 04:46:29;E;402;;
06/13/2007 04:46:29;E;601;;
06/13/2007 04:51:29;E;401;;
06/13/2007 04:55:29;E;402;;
06/13/2007 04:55:29;E;601;;
06/13/2007 05:00:29;E;401;;
06/13/2007 05:00:29;E;602;;
06/13/2007 05:04:29;E;402;;
06/13/2007 05:04:29;E;601;;
06/13/2007 05:09:29;E;401;;
06/13/2007 05:09:29;E;602;;
06/13/2007 05:13:29;E;402;;
06/13/2007 05:13:29;E;601;;
06/13/2007 09:13:08;E;222;;
06/13/2007 09:13:08;E;101;;
06/13/2007 09:14:54;E;102;;
06/13/2007 09:14:55;E;103;;
06/13/2007 09:19:54;E;222;;
06/13/2007 09:19:54;E;101;;
06/13/2007 09:39:16;E;102;;
06/13/2007 09:39:18;E;103;;
06/13/2007 09:44:16;E;222;;
06/13/2007 09:44:16;E;101;;
06/13/2007 09:48:22;E;102;;
06/13/2007 09:48:24;E;103;;
```



Example – Event File 4

```
##################
#
#SI5048 - Event/Failure History
#
##################
#
# SN  :  1260000196
# SN1 :  1260000234
# SN2 :          0
# SN3 :          0
#
TimeStamp;Type;Number;;
06/13/2007 04:33:29;E;401;;
06/13/2007 04:33:29;E;602;;
06/13/2007 04:37:29;E;402;;
06/13/2007 04:37:29;E;601;;
06/13/2007 04:42:29;E;401;;
06/13/2007 04:42:29;E;602;;
06/13/2007 04:46:29;E;402;;
06/13/2007 04:46:29;E;601;;
06/13/2007 04:51:29;E;401;;
06/13/2007 04:55:29;E;402;;
06/13/2007 04:55:29;E;601;;
06/13/2007 05:00:29;E;401;;
06/13/2007 05:00:29;E;602;;
06/13/2007 05:04:29;E;402;;
06/13/2007 05:04:29;E;601;;
06/13/2007 05:09:29;E;401;;
06/13/2007 05:09:29;E;602;;
06/13/2007 05:13:29;E;402;;
06/13/2007 05:13:29;E;601;;
06/13/2007 09:13:08;E;222;;
06/13/2007 09:13:08;E;101;;
06/13/2007 09:14:54;E;102;;
06/13/2007 09:14:55;E;103;;
06/13/2007 09:19:54;E;222;;
06/13/2007 09:19:54;E;101;;
06/13/2007 09:39:16;E;102;;
06/13/2007 09:39:18;E;103;;
06/13/2007 09:44:16;E;222;;
06/13/2007 09:44:16;E;101;;
06/13/2007 09:48:22;E;102;;
06/13/2007 09:48:24;E;103;;
06/13/2007 09:53:22;E;222;;
06/13/2007 09:53:22;E;101;;
06/13/2007 09:55:11;E;102;;
06/13/2007 09:55:13;E;103;;
06/13/2007 10:04:03;E;222;;
06/13/2007 10:04:03;E;101;;
06/13/2007 10:32:17;E;102;;
06/13/2007 10:32:19;E;103;;
06/13/2007 10:37:17;E;222;;
06/13/2007 10:37:17;E;101;;
06/13/2007 12:38:41;E;705;;
06/13/2007 12:38:42;E;402;;
06/13/2007 12:38:42;E;101;;
06/13/2007 12:38:43;E;204;;
06/13/2007 12:38:44;W;734;;
06/13/2007 12:38:44;E;711;;
06/13/2007 12:38:44;E;603;;
06/13/2007 12:38:45;E;619;;
06/13/2007 12:43:46;E;222;;
06/13/2007 13:01:44;E;102;;
06/13/2007 13:01:46;E;103;;
06/13/2007 13:02:22;E;610;;
```



Example – Event File 5

```
##################
#
#SI5048 - Event/Failure History
#
##################
#
# SN  :  1260000196
# SN1 :  1260000234
# SN2 :          0
# SN3 :          0
#
TimeStamp;Type;Number;;
06/13/2007 04:33:29;E;401;;
06/13/2007 04:33:29;E;602;;
06/13/2007 04:37:29;E;402;;
06/13/2007 04:37:29;E;601;;
06/13/2007 04:42:29;E;401;;
06/13/2007 04:42:29;E;602;;
06/13/2007 04:46:29;E;402;;
06/13/2007 04:46:29;E;601;;
06/13/2007 04:51:29;E;401;;
06/13/2007 04:55:29;E;402;;
06/13/2007 04:55:29;E;601;;
06/13/2007 05:00:29;E;401;;
06/13/2007 05:00:29;E;602;;
06/13/2007 05:04:29;E;402;;
06/13/2007 05:04:29;E;601;;
06/13/2007 05:09:29;E;401;;
06/13/2007 05:09:29;E;602;;
06/13/2007 05:13:29;E;402;;
06/13/2007 05:13:29;E;601;;
06/13/2007 09:13:08;E;222;;
06/13/2007 09:13:08;E;101;;
06/13/2007 09:14:54;E;102;;
06/13/2007 09:14:55;E;103;;
06/13/2007 09:19:54;E;222;;
06/13/2007 09:19:54;E;101;;
06/13/2007 09:39:16;E;102;;
06/13/2007 09:39:18;E;103;;
06/13/2007 09:44:16;E;222;;
06/13/2007 09:44:16;E;101;;
06/13/2007 09:48:22;E;102;;
06/13/2007 09:48:24;E;103;;
06/13/2007 12:38:41;E;705;;
06/13/2007 12:38:42;E;402;;
06/13/2007 12:38:42;E;101;;
06/13/2007 12:38:43;E;204;;
06/13/2007 12:38:44;W;734;;
06/13/2007 12:38:44;E;711;;
06/13/2007 12:38:44;E;603;;
06/13/2007 12:38:45;E;619;;
06/13/2007 12:43:46;E;222;;
06/13/2007 13:01:44;E;102;;
06/13/2007 13:01:46;E;103;;
06/13/2007 13:02:22;E;610;;
```

Transfer Relay Open → 06/13/2007 14:40:38;E;609;;

Generator Stop → 06/13/2007 14:43:38;E;402;;

Generator Start → 06/13/2007 14:48:38;E;401;;

06/13/2007 14:48:38;E;602;;

Transfer Relay Closed → 06/13/2007 14:49:26;E;610;;

Generator Running → 06/13/2007 14:49:26;E;104;;

Transfer Relay Open → 06/13/2007 17:46:53;E;609;;

Generator Stop → 06/13/2007 17:51:53;E;402;;

06/13/2007 17:51:53;E;601;;

Application: Information carrier

- In addition to SI-Data and parameters also other information can be stored on SD card.
  - User manual can be stored on card
  - White papers and or applications notes
  - Digital pictures of system and/or problem components
  - Detailed instructions to users for specific problems